International Telecommunication Union

QUESTION 11-1/2

Examination of digital 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

ITU-D STUDY GROUP 2 3rd STUDY PERIOD (2002-2006)

Report on Question 11-1/2 for 2005

International Telecommunication Union

THE STUDY GROUPS OF ITU-D

The ITU-D Study Groups were set up in accordance with Resolutions 2 of the World Telecommunication Development Conference (WTDC) held in Buenos Aires, Argentina, in 1994. For the period 2002-2006, Study Group 1 is entrusted with the study of seven Questions in the field of telecommunication development strategies and policies. Study Group 2 is entrusted with the study of eleven Questions in the field of development and management of telecommunication services and networks. For this period, in order to respond as quickly as possible to the concerns of developing countries, instead of being approved during the WTDC, the output of each Question is published as and when it is ready.

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Chapter I

Introduction

The transition from analogue to digital broadcasting technologies is expected to be universal over time. However, this transition will not progress evenly in all countries of regions. Although satellite digital broadcasting services (sound and television) have been or will soon be introduced worldwide, terrestrial digital broadcasting is in the early stages in many countries.

In the field of television and radio (jointly referred to as “broadcasting”), “switchover” refers to the migration process from analogue to digital broadcasting, starting with the introduction of digital and ending with the switch-off of analogue broadcasting. Many routes are possible in terms of the speed and length of the process, the parties involved, and the degree of government intervention. Each country follows its own switchover path, often influenced by local broadcasting legacy.

Switchover implies much more than a technical migration. Considering the role of TV and radio in modern societies, that impact is not only economic but also social and political. Switchover affects all segments in the broadcasting value-chain, namely: content production, transmission and reception. All require technical upgrading to support digital broadcasts. The main challenge is on the reception side: to replace or upgrade the huge installed base of analogue receivers. This can be done with integrated digital television or radio receivers, or “set-top boxes” connected to the analogue TV set. Moreover, connection points (antennas, dishes, cabling) must often also be adapted.

This report provides information on and an overview of digital sound broadcasting and digital terrestrial television broadcasting (DTTB) technologies and systems migration. It is to be improved to reflect insofar as possible the problems faced in the deployment of digital terrestrial broadcasting, to describe available technologies to address those problems and to propose adequate recommendations, to those countries in the process of migration from analogue to digital systems, for improving their digital broadcasting networks (Chapters II and III).

Chapter III describes the different methods allowing transition from analogue to digital terrestrial broadcasting systems.

Moreover the Report identifies the economical and development aspects of proposed and existing digital sound, television and cable broadcasting systems that have particular impact on all countries, with particular attention to receiver costs and, at the same time, identify transition techniques from terrestrial analogue to digital broadcasting, taking into consideration the experiences of Member States and Sector Members and those studies undertaken by ITU-R. Subchapter 3.3 gives general results on this new market.

Chapter IV presents the results of the first session of the Regional Radiocommunication Conference held in May 2004 in Geneva, and preparations for the second session in May 2006, on the planning of T-DAB and DVB-T in 118 countries.

Following Chapter V (Conclusions), Chapter VI (Case studies) is intended to demonstrate the existing and planned transition from analogue to digital system.

1.1 Digital sound broadcasting

The migration from a radio service dependent primarily on the application of analogue technologies to one that is based on digital technologies has been evolving over the past 20 years with the emergence of performant algorithms, the evolution of computing power and the availability of digital signal processing (DSP) devices required to allow the introduction of digital sound broadcasting, first in the studio, then in the primary and secondary contribution network, and finally in the consumer area at affordable prices. (According to Moore's Law, the power of computation doubles every 18 months, and thus speeds up the process of the introduction of digital technologies). The digital techniques applied to the modulation scheme provide transparent channels. The quality of each part of the sound broadcasting chain has to be close to perfect; the weakest element will be the bottleneck and the final quality will depend on it. Consequently, digital techniques will be applied from the studio up to the contribution network even to feed analogue transmitters such as AM and FM transmitters and obviously to feed digital broadcasting transmitters (DAB, DRM, etc.).

The main advantages of a migration from analogue sound broadcasting to digital are:

a) Better sound reception

Since the introduction of new components and devices such as CD players and MP3 players the public has wanted better audio quality, and even data broadcasting service capabilities.

At the end of the 1990s, European countries developed a new broadcasting service based on OFDM technology, using "state of the art" technologies such as T-DAB audio encoders. T-DAB has consequently constituted the development base of other worldwide systems: DRM, IBOC, DVB-T.

b) Attractive new content/programmes

The introduction of digital technologies and highly efficient audio/video compression allow the introduction of numerous programmes (contents) compared with analogue systems, along with very high quality sound (FM as in the AM bands and CD quality on T-DAB as in stereo sound and multichannel surround sound systems (the 5.1 system for example) accompanying data presentation (programme guides, traffic information). Moreover, the digital sound systems can provide still pictures. In the case of video and/or data requirements, it is necessary for the listener to acquire a dedicated receiver.

The listener benefits from a number of new programmes as a result of the efficiency of the digital technology used: from 1 bit/hertz/s up to 4 bits/hertz/s.

c) Portability, mobility

Users want the same capabilities and more in terms of portability and mobile reception as compared with analogue systems (AM, FM).

d) Efficiency

The introduction of digital technologies allows:

a) improved frequency efficiency (less spectrum need per digital channel) in the allocated channel (more programmes) but also the use of the adjacent channel interference-free.

b) a drastic reduction in radiated power for the same coverage area: for example, for the DRM system, 80 kW instead of 250 kW peak power.

1.2 Digital terrestrial television broadcasting

The migration from a television service dependent primarily on the application of analogue technologies to one that is based on digital technologies has been evolving over the past twenty years. This television service migration is part of a natural outgrowth of the convergence of the television, telecommunications and computer arts and sciences through the shared use of digital technology.

The input and output signals of television systems, at the camera and at the receiver, respectively, are inherently analogue. Thus, the question "Why digital ?" is a natural one.

While signal degradations in the analogue signal are cumulative and the characteristics of the degradations make them difficult to distinguish from the video signal, the ability to regenerate a digital pulse train exactly renders the digital signals theoretically immune to impairments from external sources. Digital bit streams can be interleaved within a single channel. This interleaving process allows for the emission, transmission, storage or processing of ancillary signals along with the video and associated audio. Further, compression techniques based on redundancy reduction can be applied to digitized video and audio services allowing the possibility of transmitting one HDTV service or multiple standard services in an existing broadcasting analogue channel.

The arrival of the second and third generation component and composite digital video tape recorders, switchers, animated graphics and special effects machines and agreement on a serial digital signal interface by 1990 have sped up the move to implementation of the all-digital production facility. Digital production and use of digital tape recorders moved the broadcaster's practice on multi-generation editing from five generations of post-production editing using analogue technology to tens of generations using digital technology. The application of digital techniques has reduced camera set-up time from hours to near-instantaneous. Digital library systems made the location of recorded media transparent to the user. Computer control of the entire process penetrated deeply into the programme generation and distribution facility, bringing with it precise control and function repeatability.

The first use of digital broadcasting technologies has been for distribution between the studio and the transmitting sites either via satellite or terrestrial links.

Consequently the advantages of the digital terrestrial television broadcasting (DTTB) are as follows:

As well as more channels than analogue television, DTT offers advantages likely to incite viewers to buy or rent a decoder in order to receive it:

a) **Better images and sound:** evidence of the public's wish for better quality images and sound is to be seen in the way other products have fared. Compact discs, launched at the end of the 1980s turned out to be highly successful, although they were considerably more costly than vinyl discs and required a new player. Similarly, DVDs, which are a good deal more expensive than VHS cassettes and need special equipment, are currently experiencing a boom (the markets for DVDs and for DVD players have both doubled in the last two years), which shows that there is user demand for high-quality images and sound.

b) **Attractive new programmes:** the attraction must be real and sufficient to capture audiences. Three types of channel are likely to arouse viewers' interest: general channels which either innovate or differentiate themselves from existing ones; more thematic channels, sufficiently encompassing and likely to appeal to a fairly broad target audience; and local or regional channels, which respond to the social, economic, and political concerns of viewers in their immediate geographic environment. In certain areas of the world statistics indicate that up to 30% of digital TV viewers are listening to radio using DVB technologies.

c) **Portability:** in the absolute, this is the ideal technical solution; by means of an antenna integrated within or connected to the set, television can be received outdoors as well as anywhere in the house, even on a pocket set. In terms of broadcasting infrastructure, however, it will be costly, as the main transmitters will need additional relays in order to provide all viewers in the DTT coverage area with portable reception.

d) **Interactivity:** DTT is also presented as recently offering viewers with interactive services – in other words, as allowing a dialogue between the television user and a service provider – ranging from the provision of information to transaction services such as television shopping, gambling and banking. Ultimately, technological convergence should enable television to be the vector or the receptacle of multiple functions. However, the relatively slow take-up rate of the internet in some countries where it is available shows that part of the population is reluctant to use such services. Their development may also be restricted by the narrow capacities of the available frequencies. Furthermore, some people are of the opinion that the television remote control is probably not the most user-friendly tool for navigating within an interactive programme or service, and it will be some time before there is any improvement in connection and response times.

e) **Mobility:** one of the most obvious advantages of terrestrial broadcasting compared with other means of broadcasting is the capability to provide mobile reception for cars, trucks, buses and trains.

NOTA:

The available standards for digital TV and sound broadcasting can be roughly divided in two groups

- Single 8-VSB carrier codes (used in the USA standard ATSC-DTT) system is based on coding the digital information to be transmitted using amplitude only (8 levels). The modulated signal is then processed through a Nyquist filter, in order to reduce the transmission bandwidth.
- Multicarrier (various evolutions of COFDM, on which DVB-T and DAB (adopted in Europe), ISDB-T (adopted in Japan), DMB-T (developed in China), and other codes are based.

  The COFDM approach is based on splitting the data between an high number of carriers within the operation channel The digital information associated to each carrier can than be coded using amplitude and phase (e.g. QPSK, 16 QAM, 64 QAM). Together, the digital data simultaneously transmitted and associated to the different carriers constitute an OFDM symbol.

  COFDM-based codes allow the transmission through the physical channel of a multiplex, consisting of several contents that can then be selected and extracted by the receiver.

  Moreover, the signal spreading over many carriers distributed over the whole channel width, together with the error-recovery systems introduced to safeguard the data integrity, make it possible to consider COFDM-based systems, like DVB-T, also for the implementation of SFN networks, in which the same frequency is used for the transmission over adjacent coverage areas and the implied fading due to co-channel interference between signals originated by transmitters operating on the same frequency is recovered due to the COFDM system characteristics. Commercial SFN networks (in DVB-T) have been rolled out for instance in parts of the territory of Australia, Spain and Germany.

  The same high immunity to interferences makes COFDM digital broadcasting systems also suitable for mobile reception. Specially suited to this purpose is the recently issued DVB-H standard. In this case, special attention has been paid to preserving battery life, introducing the so-called "time splicing", that enables the system to operate only when the contents of interest are being broadcast. Furthermore, an additional error-recovery system further enhances the system robustness.

1.3 ITU activities

The three ITU Sectors, each within its own sphere of competence, are responsible for activities and studies relating to ITU-D Question 11-1/2. It should be noted that a summary of the Questions and topics under study, as well as details of approved Recommendations and handbooks having a particular bearing on developing countries, are provided in ITU-D Study Group 2's report on Question 9-1/2.

In this report, attention is drawn to the main points pertaining to Question 11-1/2:

a) ITU-R

SG 1: Spectrum management

- Recommendation SM 1047-1 "National spectrum management"
- Report SM 2012-2 "Economic aspects of spectrum management"
- Handbook on Spectrum Monitoring, 2002
- Handbook on National Spectrum Management, 2005

SG 3: Radiowave propagation

- Recommendation ITU-R P.1546-2 "Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 3 000 MHz". This revised Recommendation replaces the two former Recommendations P.370-7 and P.529-3, which were the two main Recommendations containing propagation curves for use in predicting field strengths in the case of terrestrial mobile and broadcasting service systems.
- Handbook on "Terrestrial land mobile radiowave propagation in the VHF/UHF bands" (2002).

SG 6: Broadcasting services

In particular the activities of Working Party 6E and former Task Group 6/8 relating to the preparation of the first phase of the regional radiocommunication conferences (RRC-04) with the task of updating the Stockholm 1961 Plan for television and the 1989 Plan (see Chapter IV of this document).

b) ITU-T

SG 9: Integrated broadband cable networks and television and sound transmission

This is the lead study group on integrated broadband cable and television networks, with responsibility for studies relating to:

- the use of cable and hybrid networks, primarily designed for television and sound programme delivery to the home, such as integrated broadband networks to also carry voice or other time critical services, video on demand, interactive services, etc.
- the use of telecommunication systems for contribution, primary distribution and secondary distribution of television, sound programmes and similar data services.

In ITU-T Study Group 9, which deals with integrated broadband cable networks and television and sound transmission. The following Questions and their relevant recommendations are to be followed:

Question 6/9 – Conditional access methods and practices for digital cable distribution to the home

Question 12/9 – Cable television delivery of advanced multimedia digital services and applications that use internet protocols (IP) and/or packet-based data

Question 13/9 – Voice and Video IP Applications over cable television networks.

Study Group 9 is responsible for coordination with ITU-R Study Group 6 on matters relating to broadcasting.

SG 15: In ITU-T Study Group 15 which covers optical and other transport networks, the following Questions and relevant associated Recommendations will be covered:

Question 1/15 – Access network transport

This Question maintains a comprehensive standards overviews that is updated on a regular basis and can be found at the following website address: www.itu.int/ITU-T/studygroups/com15/lead.html

SG 16: Multimedia services, systems and terminals

c) ITU-D

The Rapporteur's Group on this Question 11-1/2 is the main actor in the ITU-D Sector on this issue.

d) Regional Radiocommunication Conference (RRC)

Following the consultations initiated in 2000 regarding the holding of a regional radiocommunication conference (RRC) and planning of the future broadcasting service in the bands 174-230 MHz (VHF bands) and 470-862 MHz (UHF bands) (the ITU Council in 2001 adopted Resolution 1185 for this aim), the Plenipotentiary Conference adopted Resolution 117 (Marrakesh, 2002) on determination of the planning area for terrestrial television and sound broadcasting in those bands at the regional radiocommunication conference.

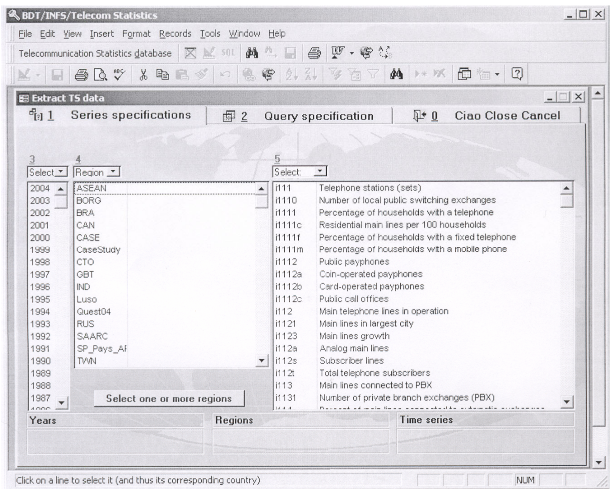
At its 2003 session, the Council modified Resolution 1185 to take account of the decisions taken by the Plenipotentiary Conference (Marrakesh, 2002) and draw up the agendas of the two sessions of the RRC. In accordance with Council Resolution 1185 (modified, 2003), a Report was drawn up in Geneva during RRC-04 (May 2004). It served as the basis for the work of the first session of the RRC, with a view to facilitating the planning exercises prior to the second session and the form in which administrations should submit their requirements. The first session of the conference took place from 10 to 28 May 2004 in Geneva: **See Chapter IV**.

e) ITU World Telecommunication Indicators Database (8th Edition 2004)

The *World Telecommunication Indicators Database* contains time series data for the years 1960, 1965, 1970 and annually from 1975-2003 for around 80 communications statistics covering telephone network size and dimension, mobile services, quality of service, traffic, staff, tariffs, revenue and investment. Data for 2003 are available for selected indicators such as main telephone lines in operation, mobile cellular subscribers and internet users. Selected demographic, macro-economic, broadcasting and information technology statistics are also included.

The data are collected from an annual questionnaire sent out by the Telecommunication Development Bureau (BDT) of ITU. Additional data are obtained from telecommunication ministries, regulators and operators and from ITU staff reports. In some cases, estimates are made by ITU staff; these are noted in the database.

We give hereafter the main screen of the Database:



- For the broadcasting, the database includes:
- Television receivers
- Television households
- Cable television subscribers
- Home satellite antennas

About data country example, it is given here after the France example.

Table 1 – Example concerning France in ITU World Telecommunication Indicators Database

Country	Time series	Series notes	1998	1999	2000	2001	2002
France	Cable TV subscribers	Source: AF	2'600'000.00	2'850'000.00	2'974'000.00	3'375'000.00	3'593'000.00
France	Home satellite antennas	Source: SE	3'260'000.00	3'920'000.00	4'300'000.00	4'740'000.00	5'010'000.00
France	Households passed by cable television				8'395'668.00	8'493'204.00	8'810'270.00
France	Per cent of households with a radio						
France	Per cent of households with a television		94.06	93.41	93.66	94.72	95.00
France	Percent of population covered by radio broadcasting						
France	Percent of population covered by TV broadcasting						
France	Radio equipped households						
France	Radio licence households						
France	Radio sets	Source: UN					
France	Television equipped households	Until 1994,	22'280'000.00	22'380'000.00	22'724'000.00	23'283'010.00	23'411'000.00
France	Television licence households						
France	Television receivers	Source: Ur	36'000'000.00	36'500'000.00	37'000'000.00	37'500'000.00	37'700'000.00
France	Televisions per 100 inhabitants		61.65	62.26	62.83	63.19	63.22

Note: Related statistical and market analysis publications are also available. For details of these reports, please consult our website at www.itu.int/ITU-D/ict (Publication notice n° 191-04)

f) World Telecommunication Development Report (2003)

This Report "Access Indicators for the Information Society" gives statistics, about broadcasting, in the chapters:

1) § 18 – Broadcasting (Pages A 72 up to A 75)

Radio and Television about households, As % of total households and Population coverage in different country categories: Low Income (59 countries), Lower Middle Income (50 countries), Upper Middle Income (29 countries) and High Income (41 countries).

The table abstract is the following:

	Radio			**Television**		
	Households (000s) 2002	As % of total households 2002	Population coverage 2002	Households (000s) 2002	As % of total households 2002	Population coverage 2002
World	702'355	69.3	95%	1'151'607	75.3	86%
Africa	89'478	59.2	93%	57'975	38.2	69%
Americas	223'512	95.8	95%	229'250	94.4	94%
Asia	247'235	54.0	96%	574'458	69.0	91%
Europe	134'757	82.2		281'196	96.7	99%
Oceania	7'373	96.3	100%	8'728	84.5	98%

2) § 19 Multichannel TV (Pages A 76 up to 79)

Cable TV subscribers, home satellite antennas and cable modem subscribers statistics are given and the abstract is the following:

	Cable TV subscribers		**Home satellite antennas**		**Cable modem subscribers**	
	Total (000s) 2002	As % of TV households 2202	Total (000s) 2002	As % of TV Households 2002	Total (000s) 2002	As % of cable TV subscribers 2002
World	351'097.6	31.8	99'665.2	14.6	23'972.9	7.0
Africa	188.6	0.3	9'192.7	21.7	–	–
Americas	96'628.5	43.4	22'287.3	10.7	13'390.5	14.1
Asia	180'747.9	33.3	22'342.7	15.7	6'447.6	3.7
Europe	71'974.4	25.7	44'957.7	16.0	3'989.4	5.6
Oceania	1'558.2	18.1	884.8	10.3	145.4	9.4

Chapter II

Technical aspects

2.1 Introduction

The implementation of digital video and/or sound broadcasting networks in the worldwide telecommunications panorama allow the multiplication of programmes received in households owing to the use of digital technologies – mainly compression techniques and no co-channel interference (for example, the use, in the case of TV, of channels which were excluded under analogue). Moreover, digital broadcasting is an important medium of the Information Society and the technologies used allow the broadband convergence of telecommunications, data, internet, video and sound with interactivity.

This chapter provides technical information for engineers and managers responsible for the implementation of digital broadcasting systems and migration from analogue to digital broadcasting systems. It is not to be expected that all existing analogue terrestrial sound and television will be replaced by digital services overnight; this may in fact take several or even many years.

Three main families of application can be noted in the broadcasting domain:

2.1.1 Digital sound broadcasting

Digital sound involves broadcasting digital audio and other data also to fixed, mobile and portable receivers. There are a number of broadcasters broadcasting in the digital radio format in various countries of Europe, North America and the Asia-Pacific Region. Digital audio broadcasting (DAB) and terrestrial integrated services digital broadcasting (ISDB-T) substitute conventional analogue radio broadcasting. In the bands below 30 MHz we have seen the development of the DRM standard which has been implemented recently in countries on an experimental or a regular basis. All the digital radio standards in the world are using COFDM, which is an effective and highly flexible means of delivering digital services especially in a complex environment with multipatch and echoes. The other benefit of the multi-carrier modulation schemes is to allow single-frequency network (SFN) techniques.

2.1.2 Digital video broadcasting

Similarly, the technology from analogue TV to digital TV is changing and digital video broadcasting has been developed and implemented by many countries. Digital broadcasting offers the potential of having more channels using the digital compression techniques like MPEG-2. Unfortunately there is currently no global sound coding systems standard, resulting in a number of different digital television standards emerging from Europe, Japan and North America.

Europe and other areas of the world have chosen to adopt the DVB standard which is compatible for DVB-T, DVB-C and DVB-S. For multimedia, the MHP 1.1 specification has been adopted. Likewise, for data broadcasting, DVB-data allows a wide variety of different and fully interoperable data services to be implemented. DVB-T allows the provision of various services in the multiplex such as radio, SDTV, EDTV (16/9), HDTV, various kinds of sound from monophony up to the 5.1 surround system, and finally fixed, portable and mobile TV.

Japan has developed the ISDB system where radio, SDTV, HDTV and mobile TV can be flexibly allocated pieces of the overall service bandwidth. The BML standard for multimedia to be harmonized with DVB-MHP and OCAP for digital cable systems are being considered.

Similarly, in the United States, the ATSC (or DTV) system has been developed by Grand Alliance for terrestrial broadcasting and cableLabs is the digital cable delivery standard. The DASE (DTV Architecture for Software Environment) standard for multimedia was issued in January 2002. But there is no interoperability between the cableLabs, ATSC and DSS standards for digital satellite (DSS is closed to DVB-S).

ITU has been working to ensure the compatibility and interoperability required amongst different electronic devices worldwide, even though it is difficult to bring the regional organizations and operators under the same umbrella.

Although DVB-T has just been tested or put into practice, the satellite service was started a few years ago in the United States, United Kingdom, Japan and other countries. The real threat for the smooth adoption of DTV is the cost of the TV receivers, which need a set-top box that converts the incoming digital signal into a format that can be viewed on the TV and may contain the software to enable the utilization of interactive services. Televisions with embedded DTV receivers are already available on the market. With the increasing number of rented or sold set-top boxes, their price is now around 70 EUR.

2.1.3 Data broadcasting

This involves the delivery of multimedia content direct to a computer or other digital devices. This is effected by installing a specific data card into the receiving device for receiving the data and converting it into a format that can be utilized by the computer or other digital devices. The use of internet and the adoption of internet protocol has revolutionized the commercial market of multimedia broadcasting worldwide. There are a number of standards being developed across Europe, the United States and Japan for multimedia broadcasting and standardization has been ongoing in ITU too.

Citing the benefits of digital broadcasting technologies it is clear that migration from analogue to digital will be universal over time. The pivotal factors for the success of the technologies are the availability of higher bandwidth, cheaper receivers, frequency spectrum for efficient global usage and interoperability issues with the existing analogue networks.

Before migrating from analogue to digital broadcasting, it is always essential to identify the market. The market and consumers look for usability and quality in technology and services. However, it is proved that both digital radio and TV have a range of benefits compared with their analogue counterparts. They are:

- Better images and sound
- Attractive new programmes
- Portability
- Interactivity
- New services
- Low power consumption of the transmitters.

These factors strengthen the viability of the future digital market. The digital technologies provide opportunities for new advanced services, as now has been proved by the internet-enabled ventures (e-businesses) and a lot of companies are emerging which will satisfy the varying and sophisticated needs of consumers. The players must also be customer-focused and always ready to serve the customers and users of the technologies.

2.2 Wireless digital sound broadcasting

2.2.1 Introduction

It is clear that the world is rapidly moving towards a time when all broadcasting will be delivered to listeners and viewers using digital platforms. The replacement for FM is seen in systems such as DAB, IBOC or DRM whilst television is increasingly using DVB in one form or another. CDs, DVDs, PCs and the internet are becoming the preferred delivery and storage mechanism for consumers who wish to retain material for multiple replays. The use of digital technology in these other media has provided the opportunity to raise the quality and reliability of the sound or video delivered. Without the development of a digital AM system it was likely that the present slow decline in listeners would lead to progressively less use of these bands.

2.2.2 Amplitude modulation broadcasting in HF bands

AM broadcasting developed in the early part of the twentieth century and the number of broadcasters and listeners grew rapidly so that today there are at least two billon radios capable of receiving broadcasts in one or more of these bands. With the development of the transistor and then the integrated circuit the real cost of these radios has dropped massively since the early days. At the same time portability has increased with reductions in size and weight whilst significantly lower power consumption has reduced the operating cost, since batteries need replacing less frequently. The rapid growth of broadcasting in these bands meant that most regions of the world today have access to at least basic radio services. In many cases these services are received not only from within the listener's country but from countries outside, providing access to a broad range of programmes delivered over the following frequency bands used below 30 MHz:

- Low frequency (LF) band – Long wave – from 148.5 kHz to 283.5 kHz, in ITU Region 1 only;
- Medium frequency (MF) band – Medium wave – from 526.5 kHz to 1 606.5 kHz, in ITU Regions 1 and 3 and from 525 kHz to 1 705 kHz in ITU Region 2;
- High frequency (HF) bands – Short wave – a set of individual broadcasting bands in the frequency range 2.3 MHz to 27 MHz, generally available on a worldwide basis.

These bands offer unique propagation capabilities that permit the achievement of:

- Large coverage areas, whose size and location may be dependent upon the time of day, season of the year or period in the (approximately) 11-year sunspot cycle;
- Portable and mobile reception with relatively little impairment caused by the environment surrounding the receiver.

There is thus a desire to continue broadcasting in these bands, perhaps especially in the case of international broadcasting where the HF bands offer the only reception possibilities which do not also involve the use of local repeater stations.

However, broadcasting services in these bands:

- use analogue techniques;
- are subject to limited quality;
- are subject to considerable interference as a result of the long-distance propagation mechanisms which prevail in this part of the frequency spectrum and the large number of users.

As a direct result of the above considerations, there is a desire to effect a transfer to digital transmission and reception techniques in order to provide the increase in quality needed to retain listeners who, increasingly, have a wide variety of other programme reception media possibilities, usually already offering higher quality and reliability.

Although the AM market still remains very significant, in terms of number of broadcasters and hours of broadcasting, it is also clear that it is in gradual decline. Other radio broadcasting delivery systems, such as FM, DAB, internet and satellite, have inexorably attracted listeners away from the AM bands, as they can provide superior sound quality. Nevertheless the AM bands still provide an attractive and cost-effective way for the broadcaster to reach a large audience. Broadcasters have made large investments in AM transmission equipment, which in many cases has many years of useful life remaining. In particular, the antennas and transmitters used for high-powered AM services represent a significant investment, for which the possibility of modification to allow digital transmission is attractive.

Whilst many broadcasters will find it possible to modify their transmission equipment to provide digital as well as analogue services, this will take time and some transmission equipment, which is unsuitable for modification, will have to be entirely replaced. Ideally this replacement would be part of the normal equipment replacement life cycle. Over this migration period both analogue and digital broadcasting will co-exist. This means that new AM radios will need to provide both analogue and digital reception well into the future. Thus the digital reception facility will be in addition to, rather than instead of, analogue reception.

NOTE – In Administrative Circular (CA/135) dated 30 June 2004 sent by the Radiocommunication Bureau (BR), Administrations were requested to submit survey data on LF, MF and HF terrestrial sound broadcasting systems. The responses received from Administrations by 14 October 2004 annexed to document ITU-R 6E/116 dated 15 October 2004 (54 countries).

2.2.2.1 Digital Radio Mondiale (DRM)

Example: Implementation of Digital Radio Mondiale (DRM) system

System overview

Today, the HF spectrum is overcrowded by analogue transmissions more especially in the bands from 4 MHz to 15 MHz or even 17 MHz.

The Digital Radio Mondiale (DRM) system is designed to be used at any frequency below 30 MHz, i.e. within the long-wave, medium-wave and short-wave broadcasting bands, with variable channelization constraints and propagation conditions throughout these bands. In order to satisfy these operating constraints, different transmission modes are available. A transmission mode is defined by transmission parameters classified in two types:

– signal bandwidth-related parameters;

– transmission efficiency-related parameters.

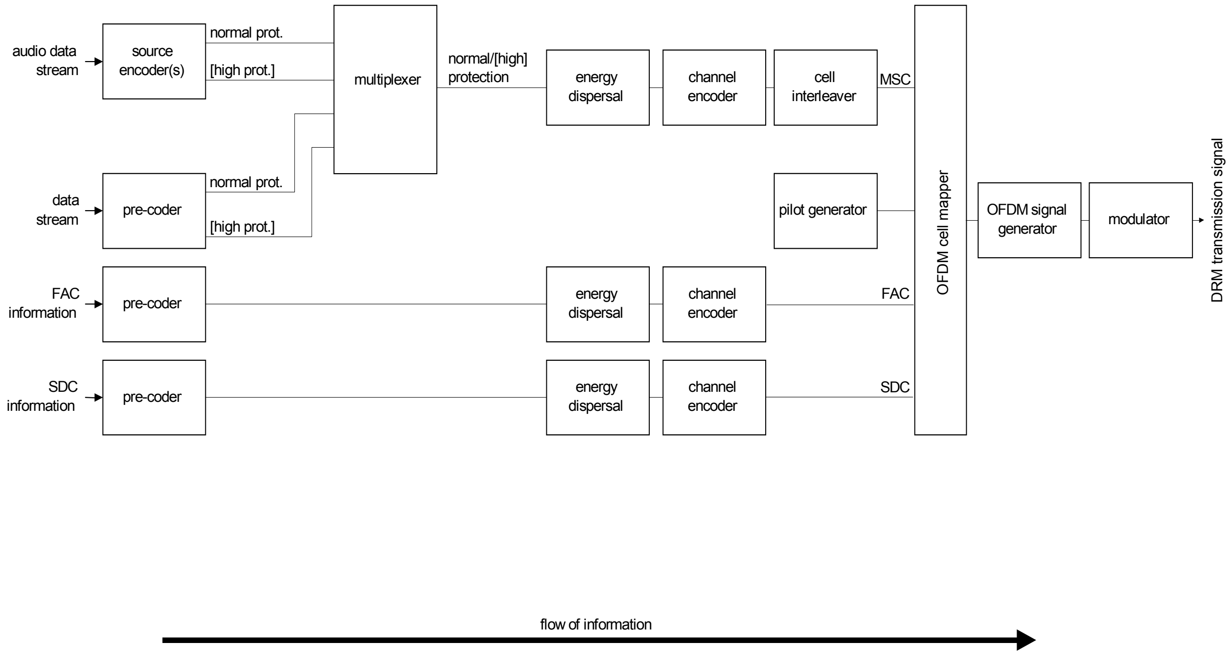
The first type of parameters defines the total amount of frequency bandwidth for one transmission. Efficiency-related parameters allow a trade-off between capacity (useful bit rate) and ruggedness to noise, multipath and Doppler.

System architecture

This section gives a general presentation of the system architecture, based on the block diagram given in Figure 1, which shows the individual parts of the system.

Figure 1 describes the general flow of different classes of information (audio, data, etc.) and does not differentiate between different services that may be conveyed within one or more classes of information.

Figure 1 – DRM transmission block diagram



The source encoders and pre-coders ensure the adaptation of the input streams on to an appropriate digital transmission format. For the case of audio source encoding, this functionality includes audio compression techniques. The output of the source encoder(s) and the data stream pre-coder may comprize two parts requiring different levels of protection within the subsequent channel encoder. All services have to use the same two levels of protection.

The multiplexer combines the protection levels of all data and audio services.

The energy dispersal provides a deterministic selective complementing of bits in order to reduce the possibility of systematic patterns resulting in unwanted regularity in the transmitted signal.

The channel encoder adds redundant information as a means of ensuring quasi error-free transmission and defines the mapping of the digital encoded information on to quadrature amplitude modulation (QAM) cells.

Cell interleaving spreads consecutive QAM cells on to a sequence of cells quasi-randomly separated in time and frequency, in order to provide robust transmission in time-frequency dispersive channels. The pilot generator provides the means to derive channel state information in the receiver, allowing for a coherent demodulation of the signal.

The orthogonal frequency division multiplexing (OFDM) cell mapper collects the different classes of cells and places them on the time-frequency grid.

The OFDM signal generator transforms each ensemble of cells with the same time index into a time domain representation of the signal. Consecutively, the OFDM symbol is obtained from this time domain representation by inserting a guard interval as a cyclic repetition of a portion of the signal.

The modulator converts the digital representation of the OFDM signal into the analogue signal in the air. This operation involves digital-to-analogue conversion and filtering that have to comply with spectrum requirements.

Source coding

Within the constraints of broadcasting regulations in broadcasting channels below 30 MHz and the parameters of the coding and modulation scheme applied, the bit rate available for source coding is in the range from 8 kbit/s (half channels) up to ≈34 kbit/s (standard channels) allowing stereophonic sound up to ≈74 kbit/s (two bundled channels) allowing audio CD quality sound.

In order to offer optimum quality at a given bit rate, the system offers different source coding schemes:

– a subset of MPEG-4 AAC (Advanced audio coding) including error robustness tools for generic mono and stereo audio broadcasting;

– a subset of MPEG-4 CELP (Code excited linear prediction) speech coder for error-robust speech broadcasting in mono, for cases when only a low bit rate is available or especially high error robustness is required;

– a subset of MPEG-4 HVXC (Harmonic vector excitation coding) speech coding for very low bit rate and error-robust speech broadcasting in mono, especially well-suited also for speech database applications;

– Spectral band replication (SBR), an audio coding enhancement tool that allows full audio bandwidth at low bit rates. It is applied to AAC for the larger bit rate.

The bit-stream transport format of the source coding schemes has been modified to meet the requirements of the DRM system (audio superframing). Unequal error protection (UEP) can be applied to improve the system behaviour in error-prone channels.

Provision is made for further enhancement of the audio system by linking two DRM signals together.

Multiplexing capabilities

The DRM system includes a multiplexing feature, which allows multiplexing of up to four different services, which can be a mix of audio and/or data. As an example, a broadcaster may wish to broadcast several different languages at the same time in the same DRM channel accompanied by the associated data. The DRM system allows the broadcast of audio and data, in the form of text and/or still pictures (slide show): a typical use of this capability could be distance-learning, or advertising, etc.

In the appropriate propagation condition, it is possible to broadcast multimedia content. The DRM system includes a subset of the DAB(EU147) Multimedia Object Transfer (MOT): EN 301 234 (ETSI).

Transmission modes

Signal bandwidth-related parameters

The current channel widths for radio broadcasting below 30 MHz are 9 kHz and 10 kHz. The DRM system is designed to be used:

– within these nominal bandwidths, in order to satisfy the current planning situation;

– within half these bandwidths (4.5 kHz or 5 kHz) in order to allow for simulcast with analogue AM signals;

– within twice these bandwidths (18 kHz or 20 kHz) to provide for larger transmission capacity where and when the planning constraints allow for such facility.

Transmission efficiency related parameters

For any value of the signal bandwidth parameter, transmission efficiency-related parameters are defined to allow a trade-off between capacity (useful bit rate) and ruggedness to noise, multipath and Doppler. These parameters are of two types:

– coding rate and constellation parameters, defining which code rate and constellations are used to convey data;

– OFDM symbol parameters, defining the structure of the OFDM symbols to be used as a function of the propagation conditions.

Coding rates and constellations

As a function of the desired protection associated within each service or part of a service, the system provides a range of options to achieve one or two levels of protection at a time. Depending on service requirements, these levels of protection may be determined by either the code rate of the channel encoder (e.g. 0,6), by the constellation order (e.g. 4-QAM, 16-QAM, 64-QAM), or by hierarchical modulation.

OFDM parameter set

The OFDM parameter set is presented in this section. These values are defined for different propagation-related transmission conditions to provide various robustness modes for the signal. In a given bandwidth, the different robustness modes provide different available data rates. Table 1 illustrates typical uses of the robustness modes.

Table 1 – Robustness mode uses

Robustness mode	Typical propagation conditions
A	Gaussian channels, with minor fading
B	Time and frequency selective channels, with longer delay spread
C	As robustness mode B, but with higher Doppler spread
D	As robustness mode B, but with severe delay and Doppler spread

2.2.3 Digital sound broadcasting in V/UHF bands

There is an increasing interest worldwide in terrestrial digital sound broadcasting (DSB) in the frequency range 30-3 000 MHz for local, regional and national coverage. ITU-R has adopted Recommendations ITU-R BS.774 and BO.789 to indicate the necessary requirements for DSB systems for vehicular, portable and fixed receivers for terrestrial and satellite delivery. The recommendations recognize the benefits of complementary use of terrestrial and satellite systems and call for a DSB system allowing for a common receiver with common processing very large scale integration (VLSI) circuits and the manufacturing of low-cost receivers through mass production.

A) Recommendation ITU-R BS. 1114-5 gives the description on systems for terrestrial digital sound broadcasting:

a) T-DAB

T-DAB (Terrestrial-digital audio broadcasting) (Digital System A of Recommendation ITU-R BS.1114) is designed to provide high-quality, multi-service digital radio broadcasting for reception by vehicular, portable and fixed receivers. It is designed to operate at any frequency up to 3 000 MHz for terrestrial, satellite, hybrid (satellite and terrestrial), and cable broadcast delivery. The system is also designed as a flexible, general-purpose integrated services digital broadcasting (ISDB) system which can support a wide range of source and channel coding options, sound-programme associated data and independent data services, in conformity with the flexible and broad-ranging service and system requirements given in Recommendations ITU-R BO.789, and ITU-R BS.774.

The T-DAB system is a rugged yet highly spectrum- and power-efficient sound and data broadcasting system. It uses advanced digital techniques to remove redundancy and perceptually irrelevant information from the audio source signal, then it applies closely controlled redundancy to the transmitted signal for error correction. The transmitted information is then spread in both the frequency and time domains so that a high quality signal is obtained in the receiver, even when working in conditions of severe multipath propagation, whether stationary or mobile. Efficient spectrum utilization is achieved by interleaving multiple programme signals, and a special feature of frequency re-use permits broadcasting networks to be extended, virtually without limit, using additional transmitters all synchronized and operating on the same radiated frequency (SFN).

b) ISDB-T_{SB}

The ISDB-T_{SB} (integrated services digital broadcasting – terrestrial for sound broadcasting) system is designed to provide high-quality sound and data broadcasting with high reliability even in mobile reception. The system is also designed to provide flexibility, expandability and commonality for multimedia broadcasting using terrestrial networks, and conform to system requirements given in Recommendation ITU-R BS.774.

ISDB-T_{SB} is a rugged system which uses OFDM modulation, two-dimensional frequency-time interleaving and concatenated error correction codes. The OFDM modulation used in the system is called BST (band segmented transmission) – OFDM. The system has commonality with the ISDB-T system for digital terrestrial television broadcasting in the physical layer. The bandwidth of an OFDM block, called an OFDM-segment, is approximately 500 kHz. The system consists of one or three OFDM-segments, thus, the bandwidth of the system is approximately 500 kHz or 1.5 MHz.

The system has a wide variety of transmission parameters such as the carrier modulation scheme, coding rates of the inner error correction code, and length of time interleaving. Some of the carriers are assigned to control carriers that transmit the information on the transmission parameters. These control carriers are called transmission and multiplexing configuration control (TMCC) carriers.

c) IBOC-FM DSB

The IBOC-FM DSB system (in band on channel FM) is a system with experimental operations in five major metropolitan areas in the United States. The system was designed to provide vehicular, portable and fixed reception using terrestrial transmitters. Although the IBOC-FM system can be implemented in unoccupied spectrum, a significant feature of the system is its ability to offer simulcasting of analogue and digital signals in the existing FM broadcasting band. This system feature would allow for a rational transition for existing FM broadcasters seeking to transition from analogue to digital broadcasting The system offers improved performance in multipath environments resulting in greater reliability than is offered by existing analogue FM operations. The IBOC-FM system offers enhanced audio quality comparable to that obtained from consumer digitally recorded media. Moreover, the system incorporates flexibility for broadcasters to offer new datacasting services in addition to enhanced audio programming. In addition, the system allows for the allocation of bits between audio and datacasting capacity in order to maximize the datacasting capabilities.

d) DRM

Some DRM partners have decided to investigate a possible extension of the DRM system in the FM bands.

B) Recommendations ITU-R BO.1130-4 and 1547 provide a full description of DSB systems: terrestrial BSS to vehicular, portable and fixed receivers in 1 400-2 700 MHz:

a) S-DAB

This is the satellite version of T-DAB (see A.1). The addition of a new transmission mode has been found to be desirable, and is being considered as a compatible enhancement to T-DAB to allow the use of higher power co-channel terrestrial retransmitters, resulting in larger area gap-filling capabilities, thus providing better flexibility and lower cost in implementing hybrid BSS (sound) for the 1 452-1 492 MHz band.

b) WorldSpace Systems

b.1 The WorldSpace system (System D_S) is primarily designed to provide satellite digital audio and data broadcasting for fixed and portable reception. It has been designed to optimize performance for satellite service delivery in the 1 452-1 492 MHz band. This is achieved through the use of coherent quadrature phase shift keying (QPSK) demodulation with concatenated block and convolutional error correcting coding, and linear amplification. The choice of TDM/QPSK modulation allows for enhanced coverage for a given satellite transponder power. Digital System D_{Ss} provides for a flexible multiplex of digitized audio sources to be modulated on to a downlink TDM carrier.

b.2 Digital System D_H, the complementary terrestrial segment of System D_{Ss}, also known as the hybrid satellite/terrestrial WorldSpace system, is designed to provide satellite digital audio and data broadcasting for vehicular, fixed and portable reception by inexpensive common receivers. The satellite delivery component of Digital System D_H is based on the same broadcast channel transport used in Digital System D_S but with several significant enhancements designed to improve line-of-sight (LoS) reception in areas partially shadowed by trees. These enhancements include fast QPSK phase ambiguity recovery, early/late time diversity and maximum likelihood combination of early/late time diversity signals.

It extends the system structure of Digital System D_S by adding the terrestrial delivery system component based on MCM. MCM is a multipath-resistant orthogonal frequency division multiplex technique that has gained wide acceptance for pervasive mobile reception from terrestrial emitters. The MCM extension improves upon the techniques which are common in systems such as DAB which is one standard utilized for terrestrial digital audio broadcast services. MCM utilizes multiple frequencies to avoid frequency selective fades resulting from channel delay spread.

c) ARIB system

The ARIB (Association of Radio Industries and Businesses) system is designed to provide satellite and complementary terrestrial on-channel repeated services for high-quality audio and multimedia data for vehicular, portable and fixed reception. It has been designed to optimize performance for both satellite and terrestrial on-channel repeater service delivery in the 2 630-2 655 MHz band. This is achieved through the use of CDM based on QPSK modulation with concatenated block and convolutional error correcting coding.

NOTE: System and service characteristics as well as radio-frequency aspects of digital sound broadcasting systems are considered in detail in the ITU-R Handbook on Terrestrial and Satellite Digital Sound Broadcasting to Vehicular, Portable and Fixed Receivers in the VHF/UHF bands, Edition 2002.

2.3 Wireless digital video broadcasting

2.3.1 Introduction

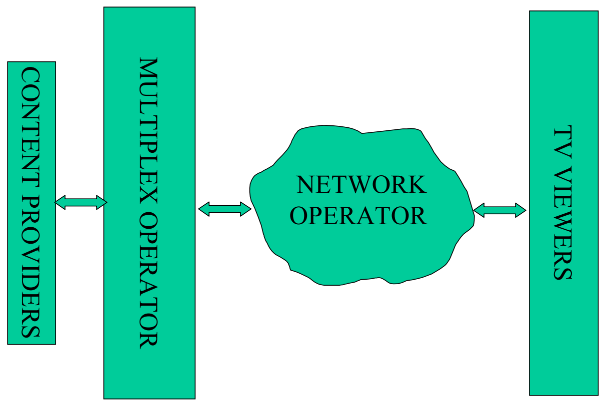
With the advent of digital television, the public authorities must consider the future and make preparations for the transition from analogue to digital television to be as smooth as possible. Some European countries have already decided to impose a cut-off date by which analogue television broadcasting will cease, with an EU-wide deadline already agreed for the year 2010.

There is therefore a need for government authorities to study the policy implications, proposed services, market (potential audience and financial volume), availability of channels for introducing digital television service and, of course, the technical integration of such a service in the existing analogue network.

The first stage in such a migration requires that a regulatory framework (law or ordinance) be set up to govern the introduction of digital television, specifying the number of multiplexes authorized (several broadcast channels per multiplex, one multiplex occupying the equivalent of an analogue channel) and the types of service.

As far as the technology is concerned, authorities are faced with a choice between existing standards already on the world market.

Figure 2 – Digital TV network structure



Four digital television systems have been developed for terrestrial broadcasting (details of these systems may be found in Recommendation ITU-R BT.1306).

The systems are:

– ATSC (system A)
– DVB-T (system B)
– ISDB-T (system C)
– DMB-T (system D)

and the ITU-R Report BT 2035 gives the "Guidelines and techniques for the evaluation of digital terrestrial television broadcasting systems".

2.3.2 ATSC system

The ATSC system was specifically designed to permit a digital transmitter to be added to each existing National Television System Committee (NTSC) transmitter in the United States, with comparable coverage and minimum disturbance to the existing NTSC service in terms of both area and population coverage. This capability is met and even exceeded.

The single-carrier digital television system is designed to transmit high quality video and audio and ancillary data using the same channel bandwidth as present television systems. The system can deliver reliably about 19 Mbit/s of data throughput in a 6 MHz terrestrial broadcasting channel and higher rates in 7 and 8 MHz channels.

The system is quite efficient and capable of operating under varying conditions, i.e. clear channel availability or, as implemented in the United States, constrained to fit 1 600 additional channels into an already crowded spectrum, and reception with roof-top or portable antennas.

The system was also designed to be immune to multipath and to offer spectrum efficiency and ease of frequency planning.

Field tests of recent enhancements to digital System C (ATSC) are described hereafter. These enhancements enable broadcasters to introduce supplemental digital audio channels in addition to the main channel digital broadcast without the need for additional spectrum. The main channel digital broadcast can continue to be used for simulcasting existing analogue programming, thereby enabling a smooth transition from existing analogue to digital broadcasts. The supplemental channels can be used to introduce new digital programming.

Digital System C permits the introduction of digital programming in the existing VHF broadcast band by inserting redundant digital carriers on either side of the existing analogue signal. The system includes two modes that facilitate the introduction of supplemental audio channels.

Scalability allows the broadcaster to reduce the number of bits devoted to main channel audio from 96 kbit/s to 48 kbit/s in less than 1 kbit/s increments. Any capacity not used for main channel audio can be reassigned to supplemental audio channels.

The extended hybrid mode allows broadcasters to insert additional digital carriers that extend inward toward the analogue host signal. These additional carriers provide 12.5, 25 or 50 kbit/s of additional capacity that can be assigned to supplemental audio channels.

In these field tests digital System C's scalability feature was used to obtain additional capacity for the supplemental channel audio. The field tests were designed to assess the mobile reception coverage of the supplemental audio channel. In particular, the tests were designed to determine if the supplemental audio channel exhibits robustness sufficient to support a stand-alone service capable of being delivered to a wide audience within the normal analogue service area of a VHF station. Although these field tests were designed to assess the coverage of the supplemental audio channel, the tests did not examine the impact, if any, on the sound quality of the main channel digital audio. It is anticipated that general population listeners will not perceive any impact from the reduction in bitrate available for main channel audio, however, this conclusion will be subject to verification in future tests.

The field tests were conducted using existing VHF stations in Washington, DC, New York City, San Francisco and Los Angeles. The test stations broadcast main channel digital signals at 64 kbit/s and used the remaining 32 kbit/s for supplemental audio. In each case, a series of radial routes close to the transmitter and extending outward throughout the station coverage area were used to assess the coverage of both the main channel and supplemental channel audio. After the completion of the data collection, an additional analysis was conducted to create an overall digital coverage area based on the radials used in the test. Propagation modeling software was used to predict overall coverage based on the test data. The contours were selected based on the area where mobile receivers would decode the main or supplemental channel to a certainty of 95%. The terrain-sensitive analysis method selected was Terrain-Integrated Rough Earth Model (TIREM) which is based on an implementation of the JSC propagation algorithm, utilizing 3-second terrain data.

The results demonstrated a robust coverage area for supplemental audio. In Washington, digital System C delivered supplemental audio to the 64.9 dBu TIREM service area containing 4 656 986 persons. This represents 88.7% of the population contained in the stations 60 dBu protected service area. In New York, the system delivered supplemental audio to the 61.0 dBu TIREM service area containing 15 747 274 persons. This represents 103% of the population contained in the station's 60 dBu contour. In San Francisco, the system delivered supplemental audio to the 66.0 dBu TIREM service area containing 1 603 323 persons. This represents 58.9% of the population contained in the station's 60 dBu contour and 107% of the population in the station's 70 dBu contour. In Los Angeles, the system delivered supplemental audio to the 70.8 dBu TIREM service area containing 4,181,551 persons. This represents 63.3% of the population in the station's 60 dBu contour and 161% of the population contained in the 70 dBu contour.

Based on these test results, it was concluded that digital System C can provide supplemental audio within a station's 60 to 70 dBu service area. (Additional details at www.gullfoss2.fcc.gov/prod/ecfs/retrieve.egi?native).

2.3.3 DVB-T system

The DVB-T system was essentially designed with built-in flexibility, in order to be able to adapt to all channels: it is capable of coping not only with clear channel but with interleaved planning, i.e. in the channels adjacent to an analogue transmission, and even co-channel operation for the same programme by different transmitters (SFN).

The multi-carrier (DVB-T) system was designed originally for the 8 MHz UHF channel spacing used in Europe and has been adapted to fit 7 and 6 MHz channels. Depending on the choice of coding and modulation parameters, data rates from 20 to 30 Mbit/s can be realized to deliver high quality digital television through the broadcasting channels. Equally, lower data rates can be employed in cases where additional ruggedness is considered to be desirable.

It also permits service flexibility, with the possibility of reception by roof-top antennas and also, if desired, of portable reception. Mobile reception is possible for quadrature phase shift keying (QPSK) and also for higher modulation orders, proven by extensive laboratory measurements and field trials under different channel conditions.

The system was also designed to be robust against interference from delayed signals, either echoes from terrain or buildings or signals from distant transmitters in a SFN. This capability will improve spectrum utilization efficiency when planning digital television services in crowded spectrum conditions such as occur in Europe.

The DVB-T system features a number of selectable parameters, allowing it to accommodate a large range of values for *C*/*N* ratio and channel behaviour, allowing fixed, portable, or mobile reception, with a trade-off in the usable bit rate. The range of parameters allows the broadcasters to select an appropriate mode for the foreseen application. For instance, a very robust mode (with correspondingly lower payload) is needed to ensure portable reception. A moderately robust mode with a higher payload could be used where the digital services are interleaved with analogue services (for example in the channels adjacent to analogue). The less robust modes with the highest payloads can be used if a clear channel is available for digital television broadcasting.

a) DVB-T variants

The DVB-T standard allows for different levels of modulation and different code rates to be used to trade bit rate versus ruggedness. As some variants can be selected as representative of the much larger set of all variants, it will be necessary to select such a sub-set for the planning conference. This sub-set is useful to avoid too many options that would otherwise need to be displayed.

The non-hierarchical variants are chosen as being typical of some expressed requirements and are close to others; for the DVB-T example, it is to be expected that channel requirements for a variant with a code rate of 2/3 will be similar to those for a variant with a code rate of 3/4, for the same modulation.

A2: QPSK, 2/3: this variant provides a low data capacity of only 6 to 8 Mbit/s but it does provide a very rugged service.

B2: 16-QAM (quadrature amplitude modulation), 2/3: the data capacity is moderate at 13 Mbit/s to 16 Mbit/s and this variant may be of interest for providing reasonably rugged services especially for portable or mobile reception.

C2: 64-QAM, 2/3: this variant has a high data capacity, 20 Mbit/s to 24 Mbit/s but provides less rugged services and is particularly sensitive to self-interference effects in large area SFNs.

b) Hierarchical variant

Hierarchical DVB-T system variants mean that the MPEG-2 bit stream is divided into two parts: the high priority stream and the low priority stream. The high priority stream is the rugged part of the hierarchical system and uses QPSK modulation and an appropriate code rate to provide the necessary protection against noise and interference. Because of the type of modulation, the data capacity is low (about 5 to 6 Mbit/s). However, the C/I ratio is worse than that of a non-hierarchical QPSK system although the data capacity is the same as that of a QPSK system of the same code rate.

The low priority stream is the more fragile part of the hierarchical system and may be either 16-QAM or 64-QAM. Not much consideration has been given to a low priority stream using 16-QAM because the data capacity of the low priority stream is about the same as that of the high priority stream. A low priority stream using 64-QAM provides about twice the capacity of the high priority QPSK stream. Its exact capacity relative to that of the high priority stream depends on the relative code rate of the two streams.

The hierarchical system variants could be used in several ways. One example would be for a combination of fixed and mobile services in the same area, where the high priority stream gives robust mobile coverage and the low priority stream provides fixed antenna reception.

c) Guard interval

OFDM, used in DVB-T, exhibits relatively long symbol periods due to its multi-carrier nature. This long symbol period provides a degree of protection against inter-symbol interference caused by multipath propagation. This protection can, however, be greatly enhanced by use of a guard interval. The guard interval is a cyclic extension of the symbol. In simplistic terms, a section of the start of the symbol is simply added to the end of the symbol.

For multiple frequency networks (MFNs), small guard intervals are used while for SFNs, larger guard intervals are required. There is a trade-off between the length of the guard interval and the data capacity. For a given DVB-T variant, a larger guard interval length implies a lower data capacity.

2.3.4 ISDB-T system

ISDB is a new type of broadcasting for multimedia services. It systematically integrates various kinds of digital content, each of which may include multi-programme video from limited definition television to HDTV, multi-programme audio, graphics, text, and so on.

Since the ISDB contains a variety of services, the system has to cover a wide range of requirements that may differ from one service to another. For example, a large transmission capacity is required for HDTV service, while a high service availability (or transmission reliability) is required for data services such as key delivery of conditional access, downloading of software, and so on. To integrate these signals of different service requirements, it is necessary for the transmission systems to provide a series of modulation and/or error protection schemes which can be selected and combined flexibly in order to meet the requirements of each service integrated.

The ISDB-T system has been designed to have enough flexibility to not only send television or sound programmes as digital signals but also offer multimedia services in which a variety of digital information such as video, sound, text and computer programmes will be integrated. It aims to make use of advantages provided by terrestrial radio waves so that stable reception can be provided by compact, light and inexpensive mobile receivers in addition to integrated home receivers using the segmented OFDM scheme.

The ISDB-T provides common elements in operation and reception between digital satellite broadcasting and communications by using MPEG-2 coding and systems in a multiplexing process.

ISDB-T also provides flexible multi-programme editing for different receiving conditions by exploiting hierarchical transmission in a transmission channel. Hierarchical modes are composed of OFDM-segments in which transmission parameters can be independent of each other.

As the ISDB-T system uses the segmented OFDM scheme for modulation, a transport stream has to be re-multiplexed and arranged into data groups (data segments) prior to OFDM framing. After channel coding, data segments are formed into OFDM-segments. Each segment has a bandwidth B/14 MHz (B means bandwidth of TV terrestrial channel: 6, 7 or 8 MHz depending the region, so one segment occupies bandwidth 6/14 MHz (~428.57 kHz), 7/14 MHz (~500 kHz) or 8/14 MHz (~571.29 kHz).

Pilot signals are added to each segment and comprize the transmission and multiplexing configuration control (TMCC) facility. The TMCC carriers (added pilots) are used for the purpose of defining signalling parameters related to the transmission scheme, i.e. to channel coding, modulation and hierarchical condition.

As a result of segmentation and the addition of the pilot signals, each segment can have its individual error protection scheme and/or type of modulation differentially coherent quaternary phase shift keying (DQPSK), QPSK, 16-QAM or 64-QAM. Each segment can then meet the requirements of an integrated service, and a number of segments may be combined flexibly to integrate a wideband service (HDTV for example).

2.3.5 Conclusions

Standard	Channels	Band	Modulation	Applicable standards
ATSC	6 MHz	UHF/VHF	8-VSB	A.52/A.53
DMB-T	8 MHz, adaptable to 6 and 7 MHz	UHF/VHF	TDS-OFDM	National (China)
DVB-T	6, 7 and 8 MHz	UHF/VHF	OFDM	ETS 300 744
ISDB-T	6,7 and 8 MHz	UHF/VHF	OFDM blocks	ARIB

With DVB, different supports are possible:

DVB system	Frequency band	Modulation	Advantages/disadvantages
DVB-S (Satellite)	– C Band (2-6 GHz) – Ku Band (10.7–12.75 GHz)	GGPSK/BPSK/8PSK QPSK	– Very wide coverage zones – Transport environment: interferences – Reception antenna is very directive – No mobile application
DVB-T (Terrestrial)	VHF: 174-230 MHz UHF: 470-862 MHz	COFDM	– Very strong modulation, insensibility to interferences and multipaths guard interval – Mobility – Limited coverage zones
DVB-C (Cable)	116-174 MHz 230-450 MHz	QAM	– Transport environment suffers little interference (minus errors correction → more useful rate) – No mobility – Cable network

The choice must be guided by a number of criteria:

a) regulatory aspects;

b) regional coordination;

c) choice of standard;

d) capacity to provide services to users;

e) technical performance;

f) migration – availability and cost of systems, including viewer equipment (television set, decoder);

g) network structure.

The above criteria are discussed below:

a) Regulatory aspects

Before digital television can enter service, it is necessary for an authorizing law to be enacted. In addition, the national regulatory body responsible for radio and television frequencies must be provided with the necessary legal means (licensing, perhaps fees) and the resources to monitor the assigned frequencies, quality of service and compliance with the technical licence terms.

The law must also specify the number of multiplexes to be deployed (according to the number of channels available, types of service and audiovisual environment within the country), as well as a timetable for deployment and a date for the cessation of analogue broadcasting and generalization of digital broadcasting. The same law, or its associated decrees, must also specify the rules to be applied in respect of the various paying services and electronic programme guide.

In a number of countries, the introduction of digital television has resulted in a reorganization of the roles of those involved in the digital television chain (content providers, the digital package operator responsible for multiplex and subscriber management, network operator(s), and so on). We will cover the subject of network structuring in Chapter 9 of this document.

The deployment of digital television calls for planning, and this is done under the auspices of ITU. During ITU 2000 Council, it was decided to revise the Stockholm 1961 and Geneva 1989, Geneva, Frankfurt and

Wiesbaden Plans with the aim of developing a new frequency allocation plan for Region 1 and for countries bordering on that region. In Europe, working groups, in cooperation with EBU, have contributed to this effort in preparation for RRC-04.

b) Regional coordination

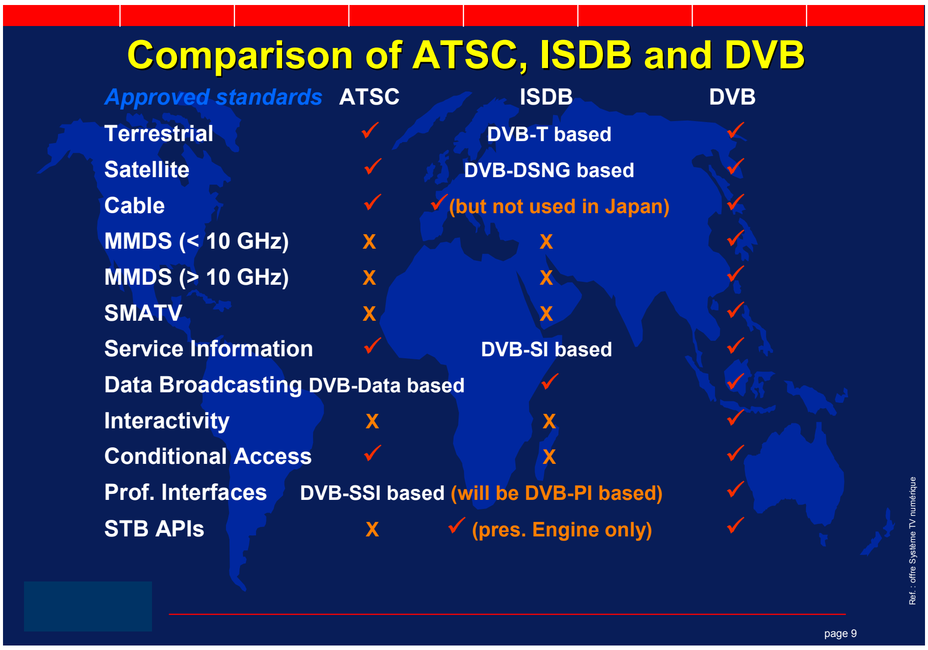
Regional allocation plans for analogue television frequencies exist at the global level for almost 117 ITU Member States. These require revision for the migration to digital television.

The existence of specific standards and technologies for analogue television at the national and regional level places constraints on the choice of a digital standard. For example, a country in which 8 MHz channels (SECAM/PAL) are used is likely to prefer a standard that will be compatible with this frequency plan.

Furthermore, the existence of digital radio and television transmissions by satellite, by cable (both copper and optical fibre) or both must be taken into account so as to optimize the network head-ends and avoid having multiple standards within the borders of one country. Certain digital television standards incorporate a system approach that takes into account all transmission media, making it possible to optimize the upstream architecture and the creation of content and multiplexes.

Exchange of content between neighbouring countries is a frequent phenomenon, and the adoption of a common standard facilitates this process. Likewise, the widespread practice of using foreign-origin programming for digital terrestrial television (DTT) means that a compatible standard will facilitate inclusion of those contents in domestic content packages or "bouquets".

By way of an example, those countries in which French is spoken will transmit broadcasts from France; if the standard selected is incompatible with the European one, transcoders will be required, adding considerably to the cost and inherently degrading both image and sound quality.



The figure shows which system aspects are covered by the various standards.

c) Choice of standard

The standards of the different systems are described in ITU-R Recommendation BT.1306: "Error-correction, data framing, modulation and emission methods for digital terrestrial television broadcasting". The frequency plan is addressed in ITU-R Recommendation BT.1368: "Planning criteria for digital terrestrial television services in the VHF/UHF bands".

Existing network, availability of transmission channels

The first step in choosing between the available standards is to consider the existing analogue standards: NTSC, PAL and SECAM. Countries currently using PAL or SECAM with an 8 MHz bandwidth are likely to choose a standard that can handle those channels, while those which use PAL or SECAM or NTSC with 6 MHz will be free to choose among all the standards. It should be borne in mind, however, that, due to filtering problems within the decoder, ATSC is only compatible with analogue M standards (NTSC, PAL-M).

These considerations are subject to technical/economic and political choices by the national government authorities.

Existing digital systems and standard harmonization

DVB-S is the international *de facto* standard for digital television broadcasting by satellite. The most widespread international standard for digital television broadcasting by cable is DVB-C. Thus, a country or a region possessing satellite or cable services will wish to capitalize on its investment by choosing a consistent DTT standard. It is conceivable that a national head-end could elaborate multiplexes for different media.

Another aspect concerns countries that wish to continue making use of foreign-origin content. Choosing a standard that is compatible with the foreign content has the advantage of obviating the need for transcoding, associated with expensive conversion equipment and loss of quality.

Choosing a compatible standard makes it possible to capitalize on investments, maintain content quality and open the networks to a variety of sources of content.

d) User service features

The choice of a standard is governed mainly by the types of services to be proposed to potential users (for example, standard definition TV versus enhanced definition TV versus HDTV, TV only versus TV, data and radio, and then, most importantly, the question of portability, mobility and fixed reception and local, regional and/or international services). This is because the standards do not all offer the same possibilities for those services, so the needs associated with the services to be offered to users will play the determining role.

Services for TV viewers

- *image format:* standard format (4:3), Enhanced Digital Television (EDTV, 16:9), High Definition Television (HDTV, 16:9);
- *audio format:* mono, stereo, multichannel (5.1 or even 6.1), the latter being offered in home cinema systems using a DVD player;
- *interactive and internet-type services*.

The type of image, sound and content can be used to determine the average data rates that will be needed for a sufficient level of quality to ensure the commercial success of DTT. For example, coverage of sporting events requires rates of 5 to 7 Mbit/s, and a 24 Mbit/s multiplex can handle no more than four such channels if an acceptable quality is to be maintained.

The transmission of radio or multichannel audio is feasible, but it must meet the needs of the viewing audience and remain affordable.

The choice of interactive services can also affect the structure of the network. Thus, if high-speed internet access is desired, the problem of the transmission network essentially becomes that of a telecommunication network and requires numerous small transmitters located close to the users (telecommunication-type gridding).

Viewer reception conditions

Many households are already equipped with a fixed receiver and rooftop antenna or a portable receiver with a whip antenna. Migration to digital television must take into account the various reception possibilities:

– fixed residential (indoor);

– portable residential (indoor and outdoor);

– mobile (pedestrian below 5 km/h, urban mobile between 5 and 60 km/h, inter-urban mobile between 60 and 180 km/h, and high-speed reception at speeds greater than 180 km/h).

The types of reception chosen will dictate channel allocation, transmitter power, the need for local repeaters to facilitate difficult urban reception (in concrete buildings for example), and the structure of the network (coverage zones, single or multiple frequency networks – SFN or MFN).

The table below provides an overview of the capabilities of the different standards in the different reception modes.

TV system	Fixed	Portable (indoor)	Portable (outdoor)	Pedestrian mobile (<5 km/h)	Urban mobile (5-60 km/h)	Inter-urban mobile (60-180 km/h)	High-speed mobile (>180 km/h)
ATSC	***	*					
DMB-T	***						
DVB-T	***	***	***	***	***	**(1)	***
ISDB-T	***	***	***	***	***	***	***

(1) The DVB consortium is working on a proposal for a specific high-performance mobile mode.

Programming sources

Broadcast programming may come from various sources:

– national;

– international;

– local sources.

National sources presuppose the availability of digital studio facilities in order to obtain the best possible image and sound quality. National programmes are compressed and multiplexed in a national head-end. Distribution of one or more multiplexes then takes place through the contribution network, which brings the digital signals *to the transmitters* or local head-ends.

International content sources presuppose, first, commercial agreements with the broadcasters who hold the rights and, in some cases, contracts with *other stakeholders*.

The standard for distributing this programming via satellite, for example, will generally be DVB-S. In the worst case, it will be necessary to implement transcoders and duplicate multiplexers to recreate the multiplexed transmission. In the best case, transmultiplexers will be required to extract the channels transmitted in the satellite multiplex (36 Mbit/s) and re-assemble them in a 24 Mbit/s multiplex, say, for 8 MHz channels.

Local channels require that studios and head-ends be available locally, to remove the original broadcast and insert the new one. Only a national MFN-type network can achieve this. By contrast, SFNs demand identical multiplex content, which obviously rules out a variety of local or regional channels. It is important to note that only multi-carrier modulation standards (DVB, ISDB or DMB) can support SFN deployment.

e) Technical performance

We have seen above that there are network constraints associated with the choice between MFN and SFN.

Essentially, SFNs offer advantages for frequency management if a single multiplex is to be broadcast across the country in a uniform manner. SFNs may also be appropriate in cases where identical services (multiplexed) are to be offered throughout a region or a city. Finally, it can greatly facilitate the provision of uninterrupted service between adjacent transmitters along major traffic arteries and railway lines.

However, a national SFN would rule out interactive services and local services. MFNs, on the other hand, demand frequency management similar to that needed for analogue television, with the exception that adjacent channels can be used, which is not the case for analogue TV.

	Satellite	**Cable**	**Terrestrial**
Europe	DVB-S (1995) ≈ 8M	DVB-C (1998) ≈ 1.2M	DVB-T (1998) ≈ 1.0M
USA	DSS (1994) ≈ 8M (DVB-S V0.9) DVB-S (1996) ≈ 4.8M	Open Cable (1998) ≈ 3-4M (DVB-C V1.05) DVB-C ≈ 1M	ATSC (1998) ≈ 50k
Japan	ISDB-S (12/2000) ? DVB-S (1996) ≈ 2.2M	DVB-C (DVB-C V1.05)	ISDB-T (2006?)
China	DVB-S	DVB-C	DVB-T et DMB-T

Number of decoders, by standard (2001)

The table makes it clear that DVB-compatible units make up the largest share of decoders currently in use. Owing to the systems approach used with DVB, only the demodulators need to be changed between DVB-S, DVB-C and DVB-T, the remainder of the decoder being the same. A vast range of decoders is on the market, from entry-level “channel zappers” to top-of-the-line interactive decoders, some of which even have their own mass storage, for digital video recorder capability.

f) Migration

1) Introducing digital television transmitters in an analogue network

During the initial phase of the introduction of digital television in a country or region, it is recommended to reserve SFN bands along major traffic routes and railway lines. While mobile television may not yet be available at the outset, it is prudent to make provision for this inevitable development, to avoid the need for revision of the frequency plan a few years hence.

If there is no intention to implement local or interactive services, one or more SFN bands can be allocated to the national network with one or more multiplexes subject to the same constraints as in the previous paragraph. There will be no interactivity and no local service on these frequencies.

As already indicated, it is also necessary to take into account the constraints associated with neighbouring countries.

The approach subsequently is, as far as possible, to make new allocations immediately below the existing digital channels.

In urban and other areas in which high-speed interactive services are planned, transmitter sites need to be reserved close to the users, using three sectorized frequencies per transmitter site. This approach uses three frequencies to minimize interference and maximize channel rates.

2) Training; building up the digital infrastructure

Digital technology is complex, and training must be provided for the teams responsible for operating digital head-ends and transmitter sites. Early training is needed to achieve operational readiness as rapidly as possible and to ensure the expertize necessary for managing and overseeing deployment. In addition, the core of experts who have benefited from advance training will be in a position to pass on their skills to their colleagues, thereby disseminating their know-how throughout the DTT operator workforce.

Anticipating this need, manufacturers have begun to offer such training, at the same time taking a progressive approach to phasing-in digital technology, offering entry-level kits with the minimum of components needed for training and indispensable test work. These can then form the core around which additional digital system components can be added to provide the full range of viewer services subsequently.

g) Network structure

In many countries broadcasters run their own analogue transmission network, using frequency bands allocated to them on a local or national level and conducting their own network operations.

In other countries, content providers approach one or more network operators, and the latter handle broadcasting for all.

With the advent of DTT, a new type of operator has appeared: the multiplex operator. Its role is to set up multiplexes in accordance with the law on audiovisual media and on the basis of agreements signed with content providers (e.g. service/quality guarantees). Hence the need for quality of service (QoS) measurement resources to be put in place, to establish compliance by the contract partner with their obligations.

The multiplex operator will provide subscriber management (billing, access control, etc.) for the broadcasters and redistribution within the contract framework. As far as interactive services are concerned, the operator will manage online purchases and impulse buying in the broadcast context, in exchange for a service fee. Another essential role of the multiplex operator will be to prepare the contents of the electronic programme guide and manage service information (SI or PSI).

The evolving nature of network organization must be borne in mind when the audiovisual law is developed, in order to ensure that the body charged with managing frequencies and transmission licences is in a position to issue the necessary requirements-based calls for tender and evaluate submissions for:

- content providers;
- multiplex operators;
- network operators.

In some cases, there may be several multiplex operators and network operators within one country; conversely, it is also conceivable that the network operator and the multiplex operator should be a single entity. In some cases, broadcasters may also apply to operate multiplexes.

2.4 Wireline digital broadcasting

In the domain of wide area network access, there are numerous wireline technology options that are presently competing for market share and acceptance. These technology options originate from both the WAN and LAN environments and include ISDN, ATM, switched Ethernet frame relay, several technologies for data transmission over coaxial (CATV) cable, and the family of digital subscriber line technologies.

Local telephone companies currently offer residential ISDN services that provide connection speeds up to 128 kbit/s and they are looking to digital subscriber line (DSL) technologies, which can provide downstream speeds beyond 1.5 Mbit/s. Other alternatives include fast downstream data connections from direct broadcast satellite (DBS), fixed wireless providers, and of course high-speed cable modems.

With near-ubiquitous coverage of broadband coaxial cable for cable TV in some countries, coaxial cable connections provide a powerful platform for providing residences and small businesses with high-speed data access. However, one-way cable television systems must be upgraded into modern two-way networks to support advanced communications services, a technically complex and capital-intensive proposition.

Digital subscriber line (DSL) technology

The introduction of new services demanding digital signals with higher and higher bit rates requires either the extension of the usable bandwidth of existing subscriber loops with sophisticated technologies or the replacement of the twisted pairs with broadband transmission media such as fibre/coaxial cables or wireless transmission.

Historically, subscriber loops contain twisted copper pairs assembled in pair cables. Subscriber loops have been under study for many years and are defined by cable type, cable length, loop structure and noise sources. The spectrum normally used for voice frequency signals of up to 4 kHz can be extended to about 500 kHz for the transmission of digital signals using DSL technologies The high cost of replacing existing subscriber loops and at the same time developments in the field of digital signal processing influenced the development of digital subscriber loop (DSL) technologies to achieve better utilization of the available bandwidth and as a result the transmission of higher bit rates. In some cases telephone signals (POTS) can use the same subscriber loop as DSL signals.

Typical DSL systems are:

HDSL has been the most widely deployed of the DSL technologies and uses two or three copper twisted pairs. Most implementations provide either 1.5 Mbit/s (T1) or 2 Mbit/s (E1) symmetrical at up to 300 m from the central office. This distance can be increased with regenerators.

ADSL holds the greatest near-term potential for providing broadband access to residential and small office or home office markets. More bandwidth is allocated for traffic from the service provider to the subscriber (downstream) than for the traffic from the subscriber to the service provider (upstream). The bandwidth allocations permit simultaneous POTS or ISDN traffic. Two ADSL versions exist: full-rate ADSL, using about 1 MHz, and ADSL Lite using about ½ MHz bandwidth. Full-rate ADSL requires splitter filter installations; ADSL Lite works without splitter filters or requires simplified in-line filter installations.

VDSL is designed for much higher bit rates and extremely short subscriber loop distances. VDSL often is used in conjunction with fibre installations, with the aid of splitter filters. Simultaneous POTS traffic is possible.

Cable TV primer

Cable systems were originally designed to deliver broadcast television signals efficiently to subscribers' homes. In order to ensure that consumers can obtain the cable service with the same TV set they use to receive over-the-air broadcast TV signals, cable operators recreate a portion of the over-the-air radio frequency spectrum within a sealed coaxial cable line.

Traditional coaxial cable systems typically operate with 330 MHz or 450 MHz of capacity, whereas modern hybrid fibre/coax (HFC) systems are expanded to 750 MHz or more.

Logically, downstream video programming signals begin around 50 MHz, and are the equivalent of two channels of over-the-air television signals. The 5 MHz – 42 MHz portion of the spectrum is usually reserved for upstream communications from subscribers' homes. Thus a traditional cable system with 400 MHz of downstream bandwidth can carry the equivalent of 60 analogue TV channels and a modern HFC system with 700 MHz of downstream bandwidth has the capacity for some 110 channels.

Cable modem access networks

To deliver data services over a cable network, one television channel (in the 50-750 MHz range) is typically allocated for downstream traffic to homes and another channel (in the 5-42 MHz band) is used to carry upstream signals.

A headend cable modem termination system (CMTS) communicates through these channels with cable modems located in subscribers' homes to create a virtual local area network (LAN) connection. Most cable modems are external devices that connect to a personal computer through a standard 10 Base-T Ethernet card or Universal Serial Bus (USB) connection, although internal PCI modem cards are also available. Layer 3 (network) OSI protocols, such as IP traffic, can be seamlessly delivered over the cable modem platform to end users.

A single downstream 6 MHz television channel may support up to 27 Mbit/s of downstream data throughput from the cable headend using 64-QAM transmission technology. Speeds can be boosted to 36 Mbit/s using 256-QAM. Upstream channels may deliver 500 kbit/s to 10 Mbit/s from homes using 16-QAM or QPSK modulation techniques, depending on the amount of spectrum allocated for the service. This upstream and downstream bandwidth is shared by the active data subscribers connected to a given cable network segment, typically 500 to 2 000 homes on a modern HFC network.

Shared network platform performance

Most cable modem systems rely on a shared access platform, much like an office LAN. Unlike circuit-switched telephone networks where a caller is allocated a dedicated connection, cable modem users do not occupy a fixed amount of bandwidth during their online session. Instead, they share the network with other active users and use the network's resources only when they actually send or receive data in quick bursts. So instead of 200 cable online users each being allocated 135 kbit/s, they are able to grab all the bandwidth available during the millisecond they need to download their data packets – up to many megabits per second.

If congestion does begin to occur due to high usage, cable operators have the flexibility to add more bandwidth for data services. A cable operator can allocate an additional 6 MHz video channel for high-speed data, doubling the downstream bandwidth available to users. Another option for adding bandwidth is to subdivide the physical cable network by running fibre-optic lines deeper into neighbourhoods. This reduces the number of homes served by each network segment, and thus, increases the amount of bandwidth available to end users.

2.5 Convergence including interactivity

For the developing countries, bridging the digital divide and the shift to the Information Society (meaning the population's guaranteed and widespread access to modern information services) consist of two main components:

a) The provision of mass access to the internet and also various specialized multimedia databases based on different specialized interactive digital services (systems for tele-education, educational programmes, network games, high-quality and traditional (low-speed) videoconferencing, home and office bank services, news-on-request, e-healthcare, business communications, including the remote finalizing of commercial deals by means of electronic signature, telework systems, video on demand, video-telephony, virtual CD-ROM, etc.).

b) The shift to mass interactive digital broadcasting.

2.5.1 Datacasting on the basis of digital broadcasting. Internet on the basis of web/carousel methods

The specifics of telecommunication and broadcasting networks in developing countries in many cases is such that it is advisable to solve the two identified problems together. This means solving the problem of the population's access on the basis of broadcasting systems. Such an approach seems appropriate for two reasons:

1) The inadequate development of telecommunication networks in many developing countries, its weak branching that does not ensure that communication channels are brought to individual users, i.e. the insufficient provision of telephone services to the population and – as a consequence – the lack of channels providing the simplest and the most widely used type of internet access (PSTN-based access).

2) Relatively few personal computers owned by population.

3) Relatively developed network of analogue broadcasting that in most cases covers all the territory of a country or – at least – its greater part.

4) Relatively high number of TV sets owned by the population.

In these circumstances a fast and relatively cheap way of solving the problem is to organize the population's access to the internet and web-type services on the basis of digital TV broadcasting. This in turn has three main components:

a) The shift to digital TV broadcasting with maximum use of the existing analogue TV broadcasting network on the basis of hybrid digital-analogue technologies, i.e. hybrid transmitters that are suitable for both analogue and digital broadcasting. In this case analogue transmitters ending their working life are substituted by transmitters with improved parameters of frequency and phase linearity (or existing transmitters are upgraded to achieve the same purpose) and are completed with digital TV signal modulators (e.g. DVB-T). Such re-use of analogue transmitters allows digital TV broadcasting in the same frequency bands that were previously used for analogue broadcasting, thus simplifying and facilitating frequency planning.

b) The insertion (encapsulation) of modern infocommunication services (primarily, the internet and web-type services) into the digital TV broadcasting stream.

c) Supplying the population with effective and cheap user receivers of digital TV broadcasting (their price should be 10 to 15 times lower than the price of a personal computer). They should also support interactive functionalities, ensure the presentation of web pages on a standard resolution TV screen and be compatible with all types of analogue TV sets owned by the population (including outdated TV sets that do not have a low frequency output).

The above approach, based on the fact that broadcasting means are omnipresent, does not exclude the possibility of providing the population with internet and web-type services in the traditional way (global modernization and reconstruction of the telecommunication network, accelerated PSTN development, creating new generation home cable networks on the basis of HFC technologies), but as it is much less expensive for both administrations and the population it is able to ensure a speedy and effective solution for bridging the digital divide. Naturally, these two approaches do not come into conflict with one another and may be implemented at the same time.

When implementing this approach, data provision at the user's residence is based on a user set-top-box (STB) and not a personal computer. In the following sections we shall deal with a wide range of questions regarding requirements for such an STB, its support of interactive functions and the function of presenting the internet on a TV screen, the software needed for that, ensuring universality and independence of the platform for such software, and organizing return channels for user STBs. In this section we examine the transmission side of internet broadcasting, primarily ways and methods of inserting (encapsulating) the internet and other modern infocommunication services data into the TV and radio broadcasting digital stream to be later received by user STBs.

2.5.1.1 Encapsulation of modern infocommunication services data (including internet broadcasting and web-type multimedia services) into the digital TV broadcasting container channel (formation of a multipurpose interactive TV broadcasting data stream)

2.5.1.1.1 Ways of organizing data broadcasting in accordance with DVB specifications

DTV broadcasting viewers are provided with internet access by including web pages in the DTV broadcasting signal. This virtually means that internet broadcasting is provided through the technical means and procedures of DTV broadcasting. To send data services together with digital video and sound programmes is perhaps the key to success in the transition from analogue to digital media. Additional services and new applications stimulate digital TV and digital radio much more than the provision of only additional TV and radio channels. An IP/DVB gateway (encapsulator) that transforms data into a DVB transport stream format is the main element of such a configuration, making it different from a DVB system providing television only. Several years ago, DVB adaptors for receiving data were usually manufactured by companies that were developing IP/DVB gateways themselves. But presently the standardization of data transmission methods in DVB systems allows adapters to be produced on ready-made chipsets by a growing number of manufacturers. In order to standardize these devices, DVB specifications assume that data may be broadcast in one of the following five ways:

Data piping – data portions are delivered by means of transport packages. There is no synchronization between data packages and other PES packages.

Data streaming – data is shaped as a contiguous stream that may only be asynchronous (i.e. it does not have any time marks, as with internet data packages).

Synchronous, i.e. tied to a permanent data broadcasting clock in order to emulate a synchronous communication channel.

Synchronized, i.e. tied by time marks to decoder inner parts and by those means to other PES packages (as in representation of video records). The data is carried by the PES itself.

Multi-protocol encapsulation (MPE) is presently the most popular technology. It is based on digital storage media – command and control (DSM-CC) and is meant to emulate the local network during the exchange of data packages.

2.5.1.1.2 Web carousel as the basic procedure for internet data encapsulation into the digital broadcasting stream

Any data carousel is a structure in the buffer data sets that may be repeated in periodical telecasts over and over again. Data sets may have any format or type. One example is data broadcasting by electronic programme guides (EPGs). Data is broadcast by means of fixed-size DSM-CC sections. Files, for instance web pages, are sent out cyclically. As full-scale internet access with a short waiting time in broadcasting is achievable only through a cyclical repetition of broadcast internet data, the basic procedure in this case is a so-called "web carousel" – a periodic repetition of a set of internet sites in the DTV broadcasting data stream (Figure 4). The web carousel changes bidirectional protocols, like HTTP, into unidirectional protocols (UHTTP). Moreover, carousel mechanisms defined by ATVEF are supported. All kinds of files, such as web pages, pictures, MP3 files, movie trailers as files, computer programmes and databases can be transmitted. If a carousel transmits video or sound files, it will have to be taken into account – unlike with streaming media approaches – that these files can be used only after the reception has been completed and the whole file has been saved. Internet live streaming additionally requires a stream connector on the inserter side and a corresponding media player on the receiver side.

Carousel cycle time depends on the amount of data and the available bandwidth for the data service. After that time, all receivers will have a copy of the content, which they can use. Local interactivity is hereby given without any return channel. The user can move unrestrictedly within this content and make use of it. The content should be appropriate to broadcasting, i.e. it is simultaneously interesting for many users.

Carousels have the further advantage that transmission errors can easily be compensated. If packets are lost, for example on a terrestrial or even mobile transmission, the corresponding files are not ready to be used until the whole packet has correctly arrived. Since notifications about transmission errors are not possible, especially if there are thousands of receivers with similar problems, the correction will take place in the next carousel cycle. This is perfectly sufficient for many applications – especially web-based information offers.

The results constitute a much more cost-effective use of internet connections via cable, telephone or mobile phone and far higher transmission bandwidths for the content mass.

An object carousel is a carousel that scrolls data carousels. Initially it was designed to provide broadcast services. Data sets are specified in the DVB network independent protocol and may be used, for example, to download data into DVB decoders.

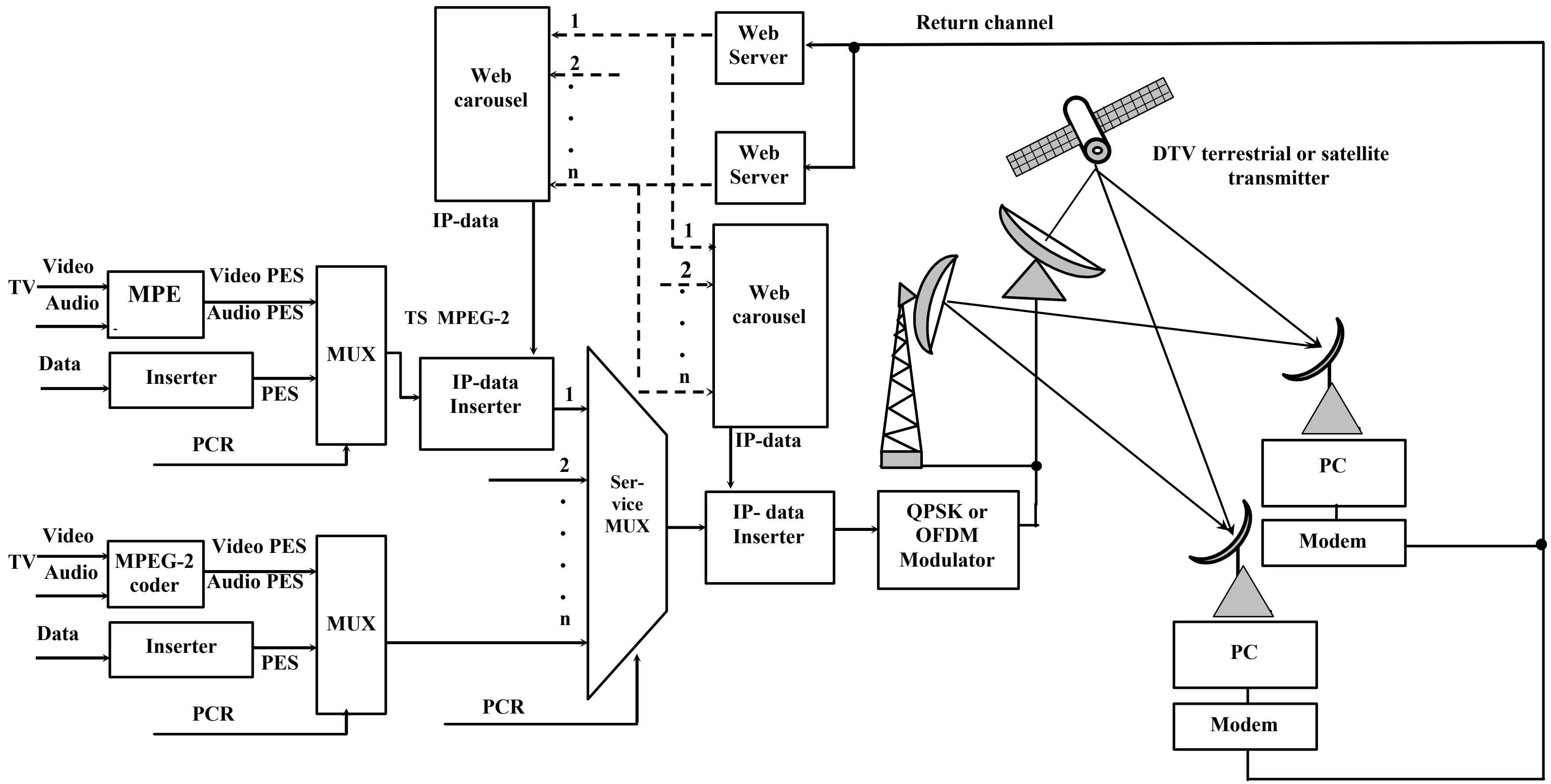


FIGURE 3: Providing DTV broadcasting viewers with the Internet access on the basis of web-carousel

To broadcast internet data, the use of multi-protocol encapsulation (MPE) charts is recommended. Return compatibility with non-standard data broadcasting charts that use piping/streaming equipment is achieved by assigning a registered service information (SI) code to each of the data formats. Each SI code that is recognized by the receiver/decoder is processed, thus ensuring the support of non-standard coding by corresponding hardware.

The format for internet data to be encapsulated into digital TV and radio broadcasting streams

IP data packets are inserted in MPEG-2 transport streams according to the multi-protocol encapsulation (MPE) standard based on digital storage media – control command (DSM-CC) (according to ISO/IEC 13818-6).

In DAB systems, IP packets are typed in as packet mode data and non-programme associated in accordance with ES 201 735 and TS 101 795 standards.

Transmission rates for data encapsulated into digital TV and radio broadcasting streams

The maximum data transmission rate depends on two parameters:

- total possible transmission rate of the modulated RF broadcasting signal; and
- free partial capacity for the data.

The first value is principally defined by the modulation. This could typically be between 14 and 24 Mbit/s in DVB-T and approximately 1.5 Mbit/s in DAB. Normally, the data service is implemented as an additional feature to a broadcast programme. This means that the main applications are television or radio programmes, with part of the bandwidth used for the transmission of data services. The usable part of the bandwidth can be provided in two different forms:

- free, non-associated resources in the form of null packets;
- a fixed, defined bandwidth set up and allocated for data services.

Null packets result from the statistical character of video contents in MPEG-2 format. They exist only in DVB. In DAB, the bandwidth for the data service must always be reserved and installed.

These null packets represent actual free resources, which can be filled with data without disturbing running programmes. The filling with data is the major function of the IP-inserter (encapsulator).

Since null packets have a statistical character and their number depends on the picture content and on the programme multiplexers used, there is no guarantee of a certain bandwidth or a certain transmission time.

There exists the possibility of using modern statistical multiplexers for TV programmes. They handle null packets so that free resources of a programme are temporarily used by other programmes in order to increase their quality (higher bandwidth). With this method, free bandwidths from calm scenes are employed in more dynamic scenes in other programmes. Consequently, there are perhaps not enough free null packets after multiplexing. The optimal situation would be if the complete bandwidth was shared out variably between all TV programmes.

Bandwidths are perfectly practicable from 500 kbit/s to 1 Mbit/s in DVB. This value is extremely good in the last-mile sector compared to all internet transmission rates, including mobile reception.

In DAB, data rates between 64 kbit/s and 512 kbit/s could become reality. A very high bandwidth is necessary for the transmission of internet radio over DAB, which is suitable for many programmes transmitted in the meantime as MP3 or other state-of-the-art audio coding methods. This approach would allow the transmission of four times more programmes of FM quality.

Routing

The typed-in data (IP packets) have to be allocated to sub-channels of the broadcast system. In DVB systems, the so-called packet-ID (PID) divides the whole bandwidth into logical connections and partial channels. IP connections can be inserted all together in a sub-channel or certain IP connections are led into different sub-channels of the broadcast system. The latter possibility can be so executed that all logical connections of a sub-net (internet sub-net mask) are inserted within a channel and so they remain separated from the other sub-nets. Therefore, IP connections can take different ways (routes) in broadcast nets if switching and distribution is done only on the broadcast level (PID-based routing).

The association of IP-address parameters of the computer network with channel numbers of the broadcast network is a function of the IP-inserter and the software element media router.

2.5.1.1.3 Possible choices for organizing the transmission of internet data encapsulated in the digital broadcasting stream along TV and radio broadcasting networks

The following scenarios for the implementation of IP in DVB-X broadcast networks can be considered:

Scenario 1: No IP

Multimedia files are delivered directly through the DSM-CC carousel mechanism and carried within the MPEG-2 transport stream (MPEG-2 TS), along with some MPEG-2 A/V services (see Figure 2). In future, MPEG-4 coded services could also be embedded in the MPEG-2 TS using a separate multiplexer.

Scenario 2: IP over carousel over MPEG-2 TS

Same as scenario 1, but the DSM-CC carousel carries the multimedia services encapsulated in the IP packets (Figure 3). An IP/DSM-CC interface is needed. IP services occupy only a portion of the total DVB-X multiplex capacity.

Scenario 3: IP over MPEG-2 TS

In this scenario, IP multicast packets are encapsulated directly in the MPEG-2 transport stream as a data service (Figure 4). The DSM-CC data stream represents a separate application, also carried within MPEG-2 TS.

Scenario 4: Carousel in IP and IP over MPEG-2 TS

Same as scenario 3, however IP packets carry a carousel data application (Figure 5). This scenario ensures an extremely robust (repetitive) file transmission to some dedicated clients that hold the specified multicast address (narrowcasting). For example, this scenario could be used for software download/upgrade of the clients.

Scenario 5: MPEG-2/4 over IP over MPEG-2 TS

Same as scenario 4, but IP packets carry not only carousel data but also additional MPEG 2 or MPEG-4 AV media streams (Figure 5). The latter can be multiplexed and transported in the form of MPEG-2 TS.

Figure 4 – MPEG-2 transport stream

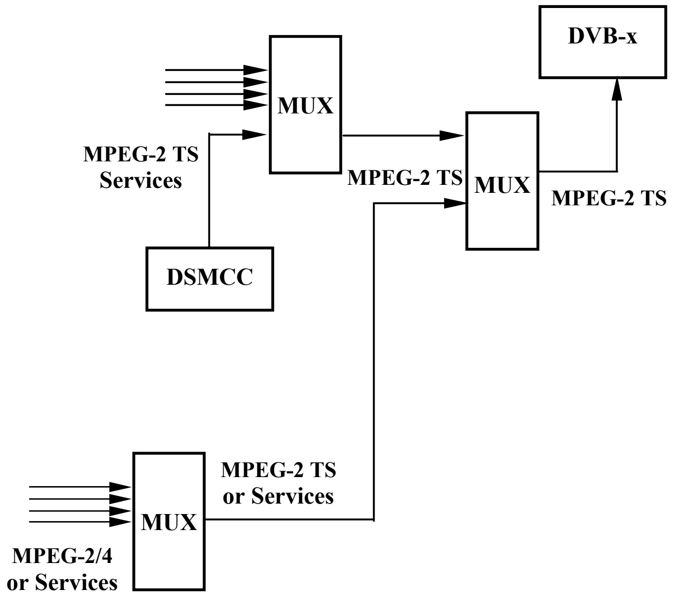


Figure 5 – IP over carousel MPEG-2 TS

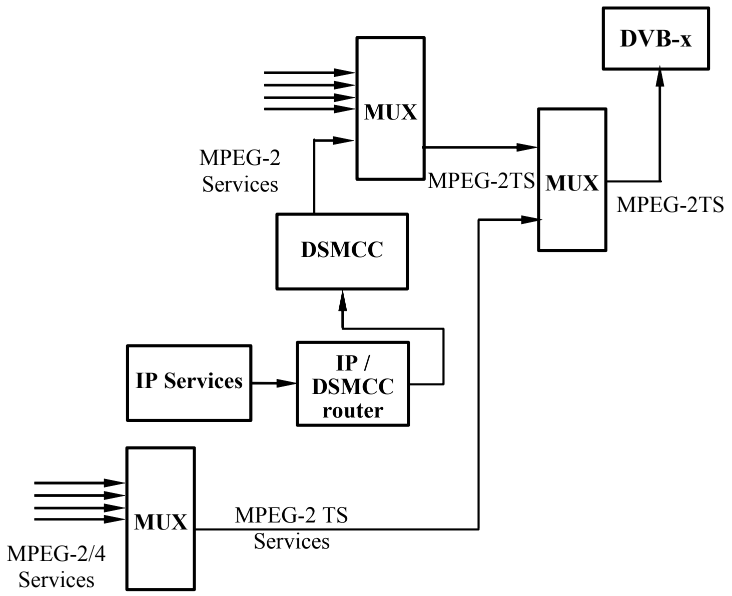


Figure 6 – IP over MPEG-2 transport stream

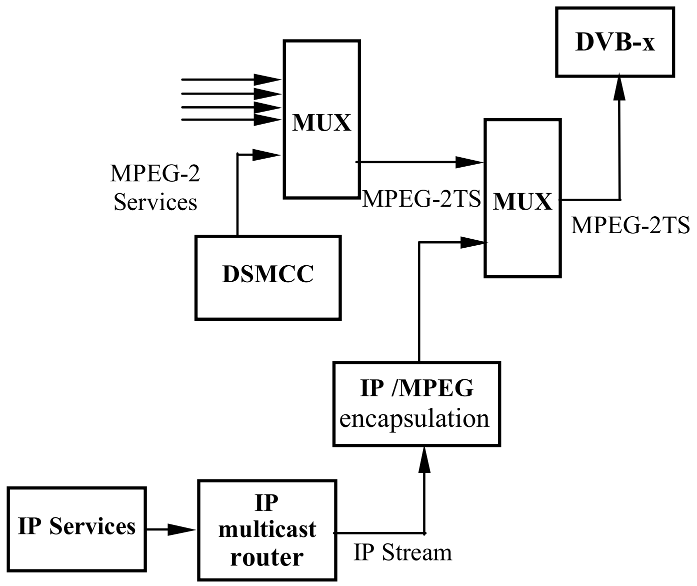


Figure 7 – Carousel in IP and IP over MPEG-2 TS

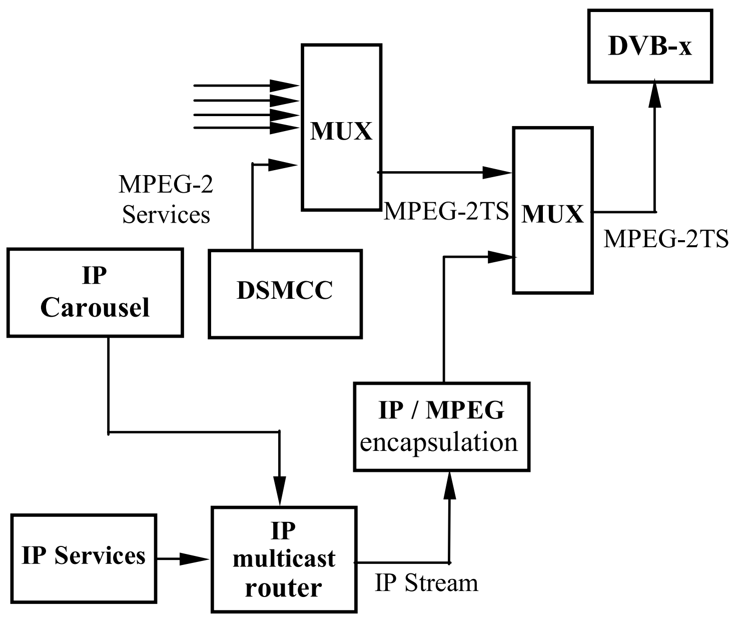
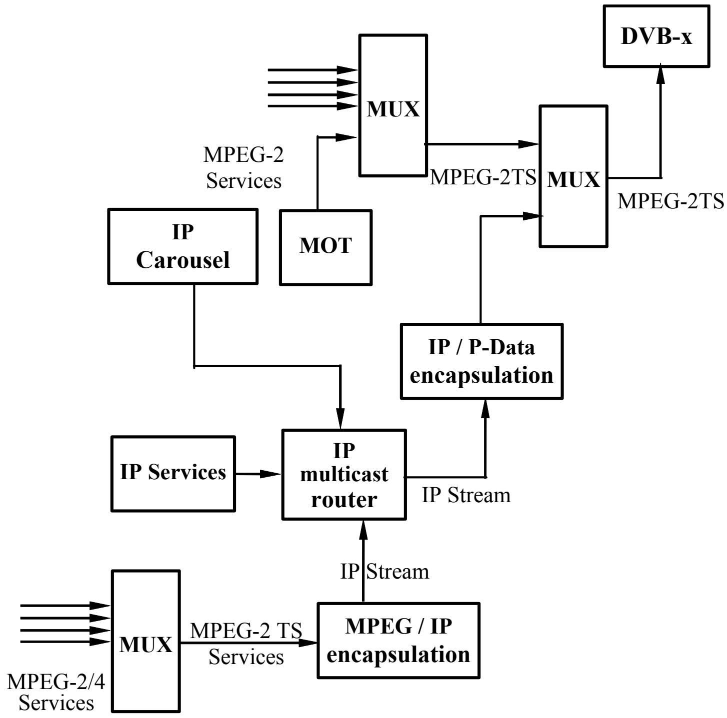


Figure 8 – MPEG-2/4 over MPEG-2 TS.



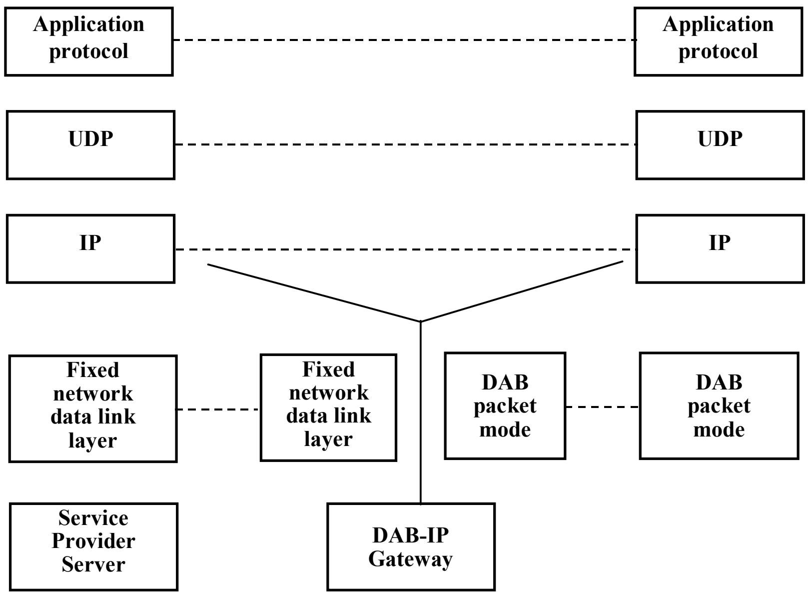
Scenario 6: MPEG-2/4 over IP and IP over DAB

Since the introduction of the Eureka 147 digital audio broadcasting (DAB) system in the mid-1990s DAB has proven its supreme qualities for distribution of broadcast services in the mobile environment. By using a 1.5 MHz wide COFDM encoded radio signal the DAB system makes it possible to broadcast a 1.2 Mbit/s multiplex of digital information to mobile terminals.

Up to now the data broadcast feature of the DAB system has been limited to the standardized applications; Dynamic Label, multimedia objects transport (MOT) Slide Show and the MOT Broadcast Web Site. These applications are designed for, and fulfill well, most of the commercial requirements for radio broadcasters who wants to enhance their services for users with integrated receivers.

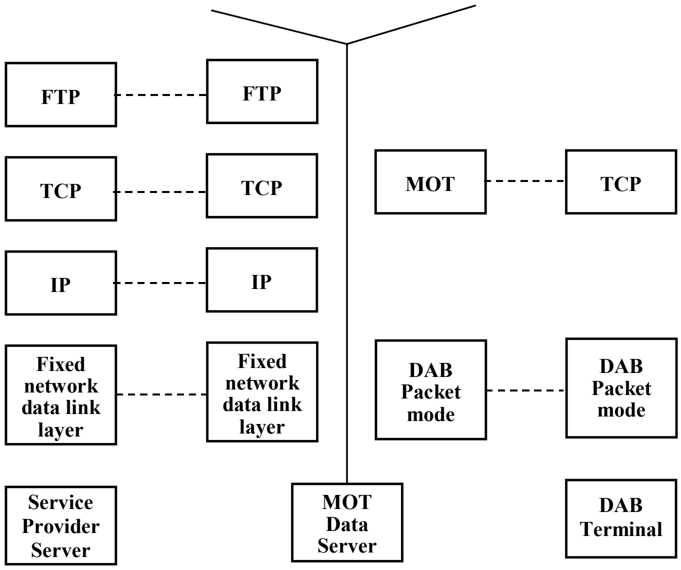
In Figure 9 the protocol view of a DAB IP application is shown. On the left side the service provider's server application generates data that shall be distributed to the client application in the DAB terminal, using the application protocol of the specific application used for the service. The data units from the application protocol are encapsulated in UDP/IP datagrams, providing the end-to-end transport from the service provider to the DAB terminal. The service provider's server is connected to a fixed data network, which transports the data from the service provider to the DAB network provider's DAB-IP gateway. This transport could be done over one single fixed network, such as an Ethernet, or over several local and/or wide area networks connected together via IP routers (not shown in Figure 9). The DAB-IP gateway receives the UDP/IP datagrams from the fixed network and encapsulate them in DAB packet mode data groups as specified in ES 201 735. The data is then broadcast over DAB, to the DAB terminals that are tuned to the DAB IP service. In the terminal the client application receives the data units that have been sent from the service provider by accessing the payload in the UDP/IP datagrams.

Figure 9 – Protocol view of a DAB IP application, showing the end-to-end use of IP and higher layer protocol



Compared to the DAB-specific MOT protocol the IP approach makes the network architecture simpler. Since MOT is a DAB-only protocol it cannot be transported over an arbitrary fixed network. This requires a network architecture where the service provider uses some other application protocol, e.g. the file transfer protocol (FTP), to transport the data to an MOT data server which performs a high level protocol conversion before inserting the data into the DAB system. A protocol view of an MOT application with its high-level protocol conversion is shown in Figure 10.

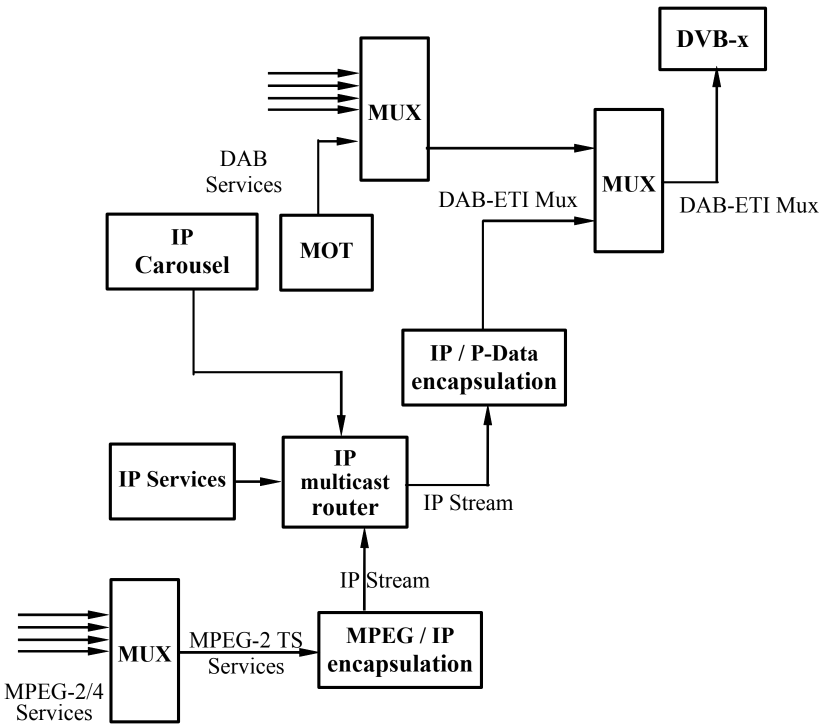
Figure 10 – Protocol view of a DAB MOT application, showing the high-level protocol conversion



From this point of view a great benefit in the IP approach is that the network provider's equipment could be much simpler than in the MOT approach, i.e. IP is a lower cost solution. Another great benefit is that the network provider does not have to convert data on the application level. Hence, the service provider takes the full responsibility for the consistency of the content, and the risk of errors due to faults in the conversion procedure is prevented.

The DAB transport mechanism is shown on Figure 11. This scenario is otherwise equivalent to scenario 5.

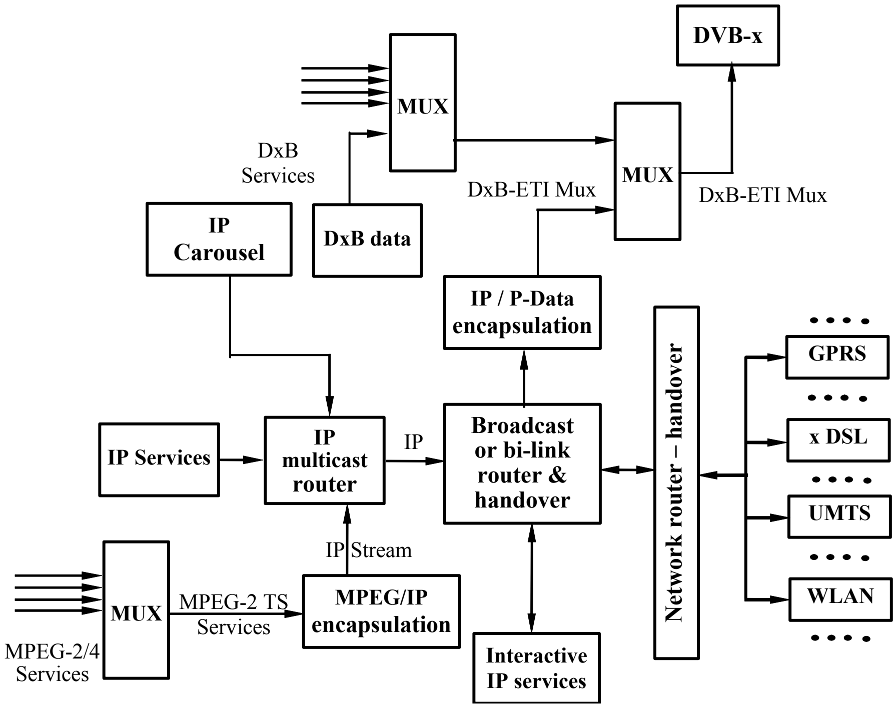
Figure 11 – MPEG-2/4 over IP and IP over DAB



Scenario 7: IP over DxB and general IP networks

This scenario is similar to scenario 5/6, however a network router is added in order to allow a bidirectional interoperability between DxB and telecom networks, such as GPRS, xDSL, UMTS, WLAN and others (Figure 12).

Figure 12 – IP over DXB and general IP network



2.5.1.1.4 Principles for choosing sites to be included in a Web carousel and specificities of this type of internet access from the point of view of user's subjective experience

The choice of sites to be included in the carousel is based on statistical data regarding the number of visits reflecting the demand for sites in such a way that most popular sites are given priority. Naturally, different carousels should include different sites and the number of such carousels (on the basis of DVB-T or DVB-S), in principle, is not limited (it becomes limited only because of a lack of free frequencies in a certain broadcasting region).

A large volume of the data stream (within the digital TV broadcasting stream) that may be assigned for internet data broadcasting (up to tens of Mbit/s) ensures a short waiting time for the user to receive requested sites (in case of an even spread of sites inside a carousel the maximum waiting time is equal to the "carousel's complete revolution" although other versions of a carousel's organization are also possible, for instance when the most popular sites are included more frequently, thus making the waiting time for them shorter).

From the technical point of view the inclusion of internet data in the digital TV broadcasting stream is done with special IP-DVB gateways. The said gateways are usually based on a multi-protocol encapsulation (MPE) technology, although in principle other technologies are also possible (data streaming for asynchronous, asynchronous or synchronized digital streams, data piping, etc.). According to the MPE procedure, internet data segments are staffed with zero bytes to make their length divisible by 188 (the length of an MPEG-2 transport package), data frames inside a segment get special headings (MAC-address or LLC/SNAP), are protected with check sums, etc. The loading of internet data into the MPEG-2 data stream is effected according to the MPEG-2 DSM-CC (digital storage media command and control) protocol (this protocol is used for support of broadband multimedia services and may work with RSVP, RTSP, RTP, SCP internet protocols). The return channel is organized in the usual way – by a modem and through a common telephone network.

We should also give some attention to the specifics of this version of internet access from a user's point of view. Traditionally, in the course of a request-data exchange between client and server a user having requested a certain site first receives its first page and then, depending on his interests and after further requests, the next pages one by one. In the case of internet access through DTV broadcasting, after a user chooses a site from a carousel («choosing» in this case means that the user allows loading into the STB memory of a certain site from the carousel and for the rest of the sites the memory remains closed), that site is downloaded as a whole (when there is enough memory this could be done for several sites). Then the user may request certain pages from the downloaded site, but they will be received and shown on the screen not from the server, but from the STB memory ("local interactivity"). Thus, even when primary waiting time (i.e. the time one has to wait for the first page of a site to be downloaded) is longer than traditional access (this may happen when the number of sites in a carousel is very large and its "full revolution" is consequently long), the user will receive the next pages instantly. This a major advantage of DTV broadcasting internet access compared with traditional access.

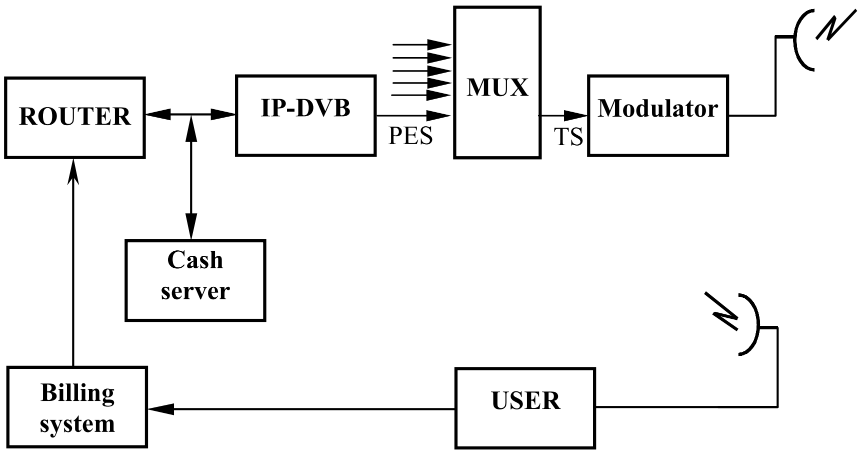
As for the rest, from the user's point of view the request-data exchange procedure would be the same as in traditional client-server access. We should note, though, an especially low (usually zero) load of the channel in the case of the former. With traditional access, the channel is used both for transmission of web pages as such and for interactive data, i.e. the names of sites requested and requests for further web pages. But in our case web pages are received within the digital TV broadcasting stream and interactive data are practically absent as the choice of site is being effected on the basis of permission/refusal for the downloading of specific internet sites into the STB memory, i.e. it is a passive procedure that does not require the sending of a request and requests for next pages are also sent within the "local interactivity" framework, thus without sending any data along the communication channel.

The modem channel may in such a case be used only for e-commerce data, i.e. specific user instructions regarding orders for some goods or services, the data on which were received from web pages, or regarding payment mode. Naturally, the user may also utilize the modem channel for internet access and thus download parts of sites in the traditional way, with the other parts – from the digital TV broadcasting channel (the load on the modem channel in such a case would still be substantially lower). But in both cases internet access is based on a digital TV broadcasting STB and no PC is needed.

2.5.1.1.5 Practical examples of organizing internet access on the basis of digital TV broadcasting

When developing a structural chart of the internet access as shown in Figure 13, it is necessary to transform IP protocol into MPEG transport stream. As was mentioned above, this is done by means of an IP-DVB gateway.

Figure 13 – Block diagram of internet access



Structural chart of internet access

In order to store frequently demanded data in the local network database, thus saving resources, a cash server is needed. A router plays the role of a gateway that connects local and outside networks. The billing system keeps statistics and checks whether a user should be allowed to access a service if that service is provided on a prepayment basis or the user has arrears on his credit. Identification is either by log-in and a username for modem connection and PPP protocol, or by a telephone number for cellular telephony and WAP or SMS protocols. Thus it would be impossible to send a query without having been authorized access. The system is thus protected from unauthorized access. MUX forms the transport stream that is fed into the modulator-receiver that broadcasts all the data: video, audio, etc. The user is provided with a digital TV broadcasting user terminal – STB.

Chart and choice of equipment on broadcasting side (broadcaster/provider)

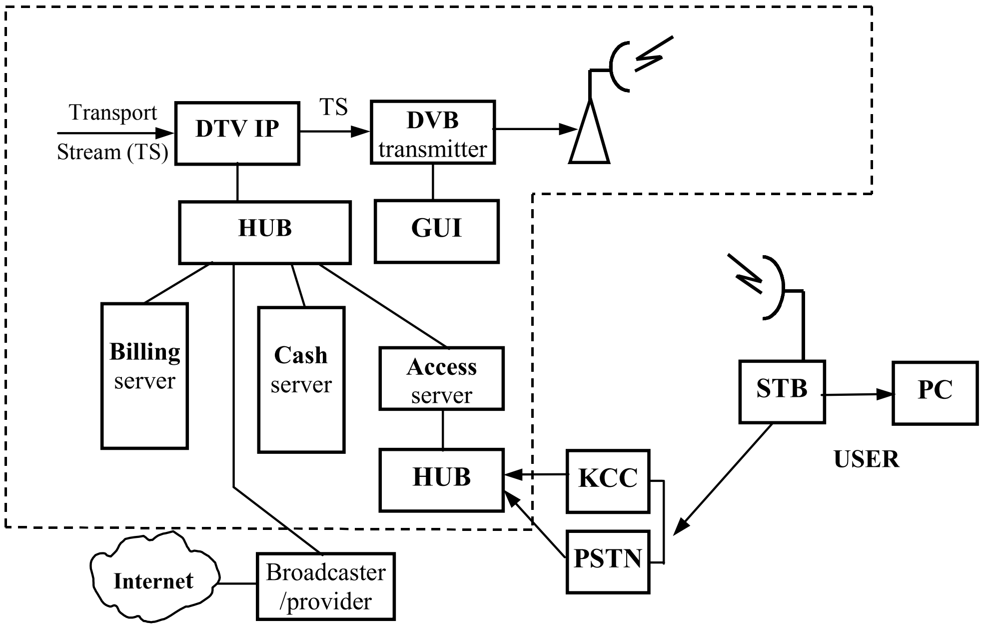
Let us now study in more detail the chart shown in Figure 12. The IP-DVB gateway ensures:

- encapsulation of supplementary data and internet data into MPEG-2 transport stream;
- support of DVB-T, DVB-C, DVB-S;
- removal of unused resources (dummy blocks);
- insertion of data into a formed transport stream and creation of an individual transport stream;
- encapsulation options:

  using maximum transmission bit rate;

  dynamic placing into the allocated frequency band;
- DVB-compatible signalling of the availability of the data transmission service;
- support of a multi-user or an individual IP connection;
- the chart of protection during power cuts;
- support of the NDIS driver and of different implementations of IP protocol.

Figure 14 – Block diagram of the IP/DVB encapsulation



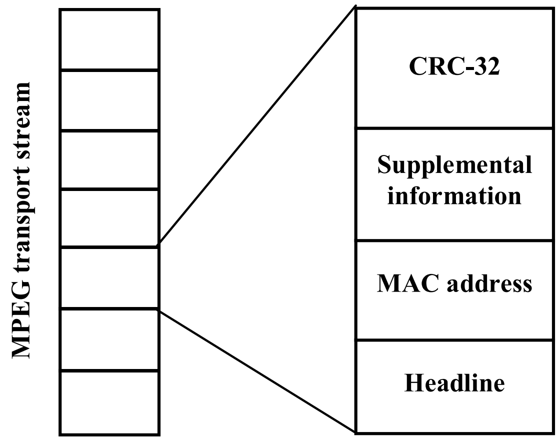
The DTV IP block inputs MPEG-2 data stream synchronous via parallel (SPI) 25-pin connector (front panel), LVDS and outputs MPEG-2 transport stream asynchronous via serial (ASI), BNC (front and back panels), 800 mV, 75 Ohm. Data stream is fed via 10/100 BaseT (100 Mbit/s), RJ45 socket, Windows NT operational system, minimum 20 Gbyte hard disk.

To feed internet data into DTV IP input inner 100 Mbit/s the network is based on the fast Ethernet technology. A computer-based billing system is connected via the HUB, to keep statistics on all data received and, using IP addresses, to calculate the traffic of each user. Usually such systems are built on the basis of the LINUX operational system (access server). When the number of users is low this may be combined with the billing system. It is meant for checking access rights when this function is not executed by the operator that organizes the user-to-provider channel. The access server is connected via the HUB to all devices used for organizing the return channel and passing data queries. Thus, when a user has arrears the server may always reject a request for data. A cash server is used to increase the amount of stored and frequently requested data. This is a database that is the first to receive a user query. When data needed are found they are provided by the cash server, otherwise the query is passed to the broadcaster/provider server. The cash server is computer-based and must have high-speed SCSI or ATA133 interfaces and high capacity hard disks. Total capacity should be 300 Gbyte minimum. The broadcaster/provider access server receives queries and internet data.

To ensure access web carousel software is also used. It allows the download of web pages and e-mail messages and supports the DVB-MHP (media home platform) standard. The stream connector is concordant with various protocols built over IP: Windows Media, QuickTime, UDP, etc. The combining of the web carousel and stream connector is effected by the media router. Such combining makes it possible to support all internet protocols and answer MHP demands.

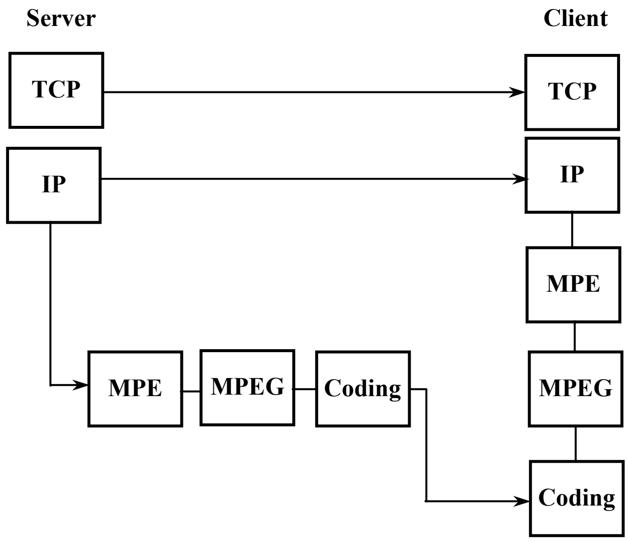
Those standards are based on the multi-protocol encapsulation (MPE) protocol. It is based on DSM-CC (digital storage media command and control). Each data frame is encapsulated into an Ethernet-like section A. PES cell in the MPEG-2 transport stream is shown in Figure 15.

Figure 15 – PES Cell in the MPEG-2 Transport Stream



Each user (i.e. each STB) is given a MAC address (for example, from user database) that corresponds to the IP address of the equipment at a remote point. Unique MAC addresses are used to identify user equipment. A general chart of IP transformation into DVB data stream is given in Figure 16.

Figure 16 – IP Transformation into DVB Data Stream



Each data frame is encapsulated by means of adding a section headline MAC address and a supplementary headline with logical link control (LLC)/subnetwork access protocol (SNAP) (when needed). Data trustworthiness is protected by CRC-32 checksum. The entire data block is called a section. Section length is regulated by adding zero bytes so that the number of MPEG-2 transport packages of 188-bit length is whole. Transport packages are assigned PIDs based on the data on the routing HUB. In order to form a virtual private network (VPN) a group of users may be assigned the same PID or each user may be assigned an individual PID. Usually packages are transmitted in Unicast (i.e. point-to-point) mode when data are delivered by one receiver only, while other receivers receive data and then reject them as either the MAC address and/or PID do not correspond to their inner filters. Multicast transmission is also possible by means of multicast addresses. Group control is not available and should be ensured by other means (e.g. use of a terrestrial return channel).

Packages in a DSM-CC section may be scrambled by means of conditional access control that also encodes the MAC address, thus preventing the provision of the received data to other users. Encryption is controlled by bits at special positions in the DSM-CC encapsulation heading section.

The finally formed transport stream is fed into a broadcasting transmitter. The requirements for its capabilities are listed below:

- working frequency band 470-860 MHz;
- ASI input;
- outputs:

  RS-232-C connects graphic user interface;

  RS-232-C connects modem for remote control (as an option there may be an RS-485 parallel port installed for remote control);
- 2K or 8K broadcast modes;
- 224 microseconds (2K) and 896 microseconds (8K) symbol useful part length;
- QPSK, 16-QAM or 64-QAM modulation;
- 1/2, 2/3, 3/4, 5/6, 7/8 inner encoding speed;
- 1/4, 1/8, 1/16, 1/32 protection interval;
- possibility of hierarchal data transmission;
- 3 amplifying cascades;
- fluid cooling;
- 7 or 8 MHz frequency band.

Encoding and modulation are carried out in accordance with the ETSI EN300744 standard. Hierarchal data transmission is not used.

A transmitter or a group of transmitters is connected with a computer equipped with a graphic user interface (GUI).

2.5.1.1.6 Requirement for presenting web pages on a standard resolution TV screen

The importance of bridging the digital divide leads to a further substantial extension, to analogue TV sets, of the information and service functions of detachable devices initially designed to receive digital TV broadcasting only. Broad internet access by means of TV broadcasting without a PC is of particular importance and it is a part of bridging the digital divide problem.

Existing digital TV broadcasting services transmit internet data by means of special internet inserters and devices for the cyclical presentation of websites ("carousels"). But the web pages transmitted in this way can be presented with proper quality only by a PC monitor. At the same time, for a lot of countries access to the internet by means of TV broadcasting without a PC is of great importance and is a part of the digital divide problem. This calls for the reformatting and rescaling of the web pages transmitted in the digital TV broadcasting data stream in the user's STB.

An important feature of internet access based on the digital TV broadcasting STB (without a PC) is the need to present web pages on the screen of a standard resolution TV set. Below we list the problems arising from that fact and suggest some ways of solving them.

As explained above, existing DTV broadcasting services now support additional data stream broadcasting, including internet access via DTV broadcasting channels. This is realized on the basis of special web-page encapsulators and devices for the cyclical representation of internet data (web carousels) as the technical basis for delivery of internet data along DTV broadcasting channels allowing the transmission of such data, for example, within the MPEG-2/DVB data stream. But web pages transmitted this way can be presented with proper quality only on a PC monitor, but not on a standard TV screen, because the HTML format now dominating the web is not suited to TV set resolution. At the same time, internet access through digital TV broadcasting is of great importance to countries, where existing TV sets greatly outnumber personal computers. For such countries these difficulties in the presentation of web resources on a TV screen mean it is impossible to implement the cheapest form of internet access (without a PC and on the basis of DTV broadcasting) and constitute a real aspect of the digital divide problem. At the same time it is commercially and socially viable (also taking into consideration the digital divide problem) to provide internet access via broadcasting channels as soon as digital TV broadcasting is introduced in all countries. All this calls for a speedy solution of the technical problem of the quality presentation of web pages on existing TV sets, which have much poorer resolution than PC monitors.

To ensure such quality presentation of web pages on standard TV sets, the user STB set should employ software to reformat and rescale internet data received within a DTV broadcasting stream. We shall go into more detail in the following sections.

Great social importance is attached to this STB function as its implementation would lead to interactive internet access (including e-mail) by all TV viewers with a telephone connection (those without a telephone would also have full access to internet resources, but without a return channel – we shall enlarge on the means to achieve that below). In that case, a PC is not needed to provide internet access and the cost of the STB does not exceed USD 70-150, i.e. it is much cheaper than a PC. This technical solution may become an option that ensures mass internet access for low and medium income groups of users in developing countries.

There is also a high commercial potential for this STB function. The inclusion of internet sites in the DTV broadcasting stream would not be free in most cases and would allow broadcasters to get substantial profits from owners of internet commercial resources interested in mass access to their data. In practice this means that a new kind of telecommunication business is being born, with enormous growth potential. Besides, it is quite possible that profits from the chargeable viewing of internet sites by means of DTV broadcasting would be split between the owners of sites and broadcasting companies.

2.5.2 Types of terrestrial return channels, and ways and means of providing wireless return channels

- **Return channels of the interactive digital TV broadcasting STB**

The problem of organizing return channels is the most important problem when it comes to deploying digital interactive TV broadcasting and is of vital importance in providing access to the internet and other modern web-type interactive services on the basis of interactive digital TV broadcasting. Presently the most frequently used option for organizing the return channel of interactive information systems in industrially developed countries (for both internet access via a personal computer and a digital interactive TV broadcasting STB) is the PSTN-based return channel. In many cases return channels are xDSL-based. Home cable TV systems based on HFC technology where the return channel is also organized within the framework of the home network develop quite rapidly, too. It is self-evident that the said methods for organizing return channels would be widely used (and are already used) in developing countries. Still, the specific characteristics of telecommunication networks in many developing countries (their low branching, which does not provide for bringing communication channels to individual users, i.e. primarily, the insufficient provision of telephone services to the population and also the inadequate development of xDSL systems and home cable networks) make one focus on technical solutions based on radio when studying the problem of organizing STB return channels. This is also stipulated by the existence of a lot of scarcely populated territories in developing countries, where radio is also an obvious option.

In view of all the above-mentioned problems in organizing STB return channels based on PSTN, xDSL and home cable networks are not considered in this report (the corresponding technical solutions are well known, extensively used and do not call for special comment). The present report concentrates on organizing return channels on the basis of radio.

This section of the report starts with a general survey of the international standardization of interactive systems in TV broadcasting. Further on we cover in detail problems in organizing STB return channels on the basis of the DVB-RCT technical solution that was standardized recently by regional standardization organizations, its technical specificities and advantages. This section also deals with organizing terrestrial digital broadcasting return channels on the basis of technologies that are used in cable TV broadcasting and necessary changes in STB configuration. The said option in organizing return channels might also in many cases become a technically and economically effective solution.

- **DVB-RCT**

DVB-T is a powerful means to wirelessly provide broadband data to customers (both stationary and mobile), but it is mono-directional. Thanks to DVB-RCT, the DVB-T platform can become bidirectional and asymmetric. DVB-RCT can be used not only in interactive TV (voting, quiz, etc.) but also in interactive web sessions and light IP telecommunication services. Services like e-commerce also require full interactivity between users and service providers.

DVB-RCT performance

The interactive system consists of the forward interaction channel (downstream) conveyed to a user via a DVB-T-compliant terrestrial broadcast network and the return interaction channel based on a wireless VHF/UHF transmission (upstream) (Figure 17).

Downstream transmission from the base station synchronizes and provides information to all RCT terminals (RCTTs). Hence, the RCTTs can synchronously access a network and then transmit upstream-synchronized information to the base station.

The DVB-RCT system works as follows:

- The modulation scheme is OFDM for both downstream (fully DVB-T-compliant) and upstream channels; hence, several parallel carriers in the upstream may be allocated to different users for transmitting data and commands back to the base station,
- Each authorized RCTT transmits one or several low bit rate modulated carriers towards the base station,
- The carriers are frequency-locked and power-ranged, and the timing of the modulation is synchronized by the base station,
- In the base station, the upstream signal is demodulated, using an FFT process (as in a DVB-T receiver).

Figure 17 – DVB-RCT network

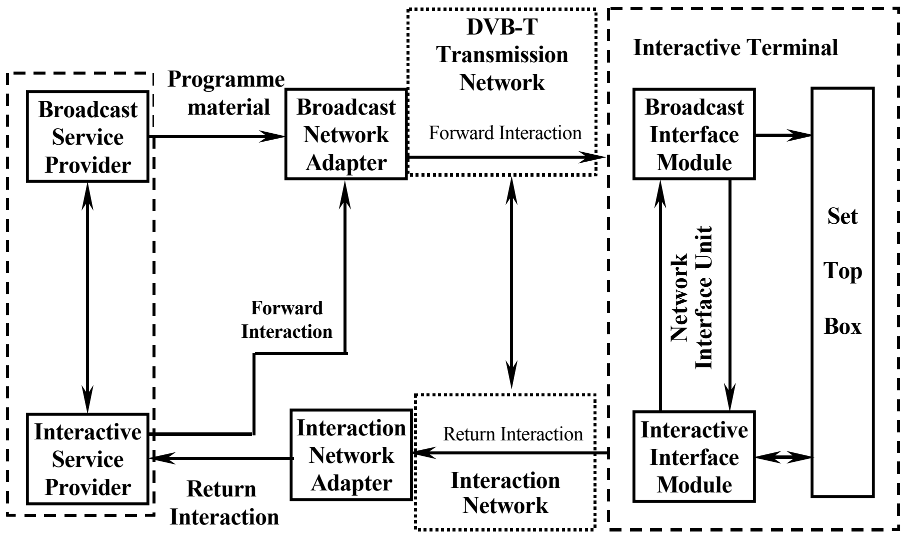


Table 4 – Summary of DVB-RCT system features

PHYSICAL PARAMETERS	
Downstream channel (DS)	OFDM, ETS 300 744 (DVB-T) compliant
Return interaction channel	Multiple Access OFDM (MA-OFDM)
Forward interaction channel (US)	Embedded in DS, compliant with ETS 300 744 (DVB-T)
OFDM carrier set	1 024 (1K), 2 048 (2K)
OFDM carrier spacing (CS)	~1K, ~2K, ~4K
Transmission modes	6 modes (as combination of 3 CS and 2 Carrier set)
Carrier shaping	Nyquist, Rectangular

PHYSICAL PARAMETERS	
Guard interval	1/4, 1/8, 1/16, 1/32 (for rectangular shaping only)
Transmission frames	TF1, TF2
Data randomization	PRBS with polynomial: $1 + X^{14} + x^{15}$
Modulation	QPSK, 16-QAM, 64-QAM
Encoding rates	1/2, 3/4
Useful data payload per burst	18, 27, 36, 54, 81 bytes (1 burst = 144 modul. Symbols)
Channel codes	Turbo or concatenated (Reed-Solomon + Convol.)
Interleaving	Random interleaver – PRBS with polynomial: $1 + X^3 + x^{10}$
Burst structures	BS1, BS2, BS3
Frequency hopping	for BS1 only (optional)
Medium access schemes	MAS1, MAS2, MAS3 (as combinations of BS and TF)
Net bit rate/carrier (range)	0.6 kbit/s – 15 Kbit/s (depending on the mode)
Maximum number of carrier/user	No limit
Service range	Up to 65 km (cell radius)
Channelization	6, 7, 8 MHz channels are supported
PROTOCOLS	
Medium access control	Specs mostly derived from EN 300 800
Access options	Fixed rate access, Contention access, Reservation access
Security	Supported (derived from EN 300 800)

Channel partitioning

To allow multiple user access, the VHF/UHF return channel is partitioned in both frequency and time domains. Each available time-frequency slot is allocated by the base station (BS) to a given user. Multiple slots allocation is possible (both on the same carrier and on different parallel carriers) to cope with bandwidth peak demands.

The DVB-RCT standard has defined three values of carrier spacing – approximately 1, 2 and 4 kHz – corresponding to three symbol durations. This provides three basic modes for the downstream DVB-T reference clock and thus for each existing channel raster (i.e. 6, 7 or 8 MHz channels). For instance, for an 8 MHz channel raster the RCT channel bandwidth varies from about 1 MHz to 7.6 MHz with 1 kHz and 4 kHz carrier spacing, respectively.

Furthermore, the DVB-RCT channel can be divided into either 1 024 or 2 048 carriers. Thanks to three carrier spacings offered, the bandwidth of the DVB-RCT channel may be 1, 2, 4 or 8 MHz. In short, in addition to its intrinsic spectrum efficiency, DVB-RCT employs any unused or underused megahertz of spectrum to provide a DVB-T return path.

Transmission frames

To structure the RF channel further – besides time-frequency partitioning – the DVB-RCT offers two transmission frames.

The first (TF1) makes use of each OFDM symbol period for a dedicated activity. Thus, the first symbol of the frame is null (which allows the BS to detect jammers). Six following symbols are devoted to the ranging procedure, while the remaining 176 symbols are used by the RCTT to transmit data.

The second transmission frame (TF2) does not use the null symbol but is made up of general-purpose symbols – 48 of them organized in 8 groups of 6 consecutive symbols. Within each group, 1K or 2K carriers are distributed over sub-channels (made of 4, 29 or 145 carriers) to perform ranging functions using the MC-CDMA technique. In short, TF2 structures the activities in the frequency domain while TF1 does so in the time domain.

Burst structures

RCTT can perform data transmission using three types of time-frequency patterns called burst structures. A data burst is made up of 144 modulated symbols into which 30 or 36 pilot carriers are inserted (for coherent demodulation in the BS).

The three burst structures allow various trade-offs between burst duration and frequency diversity. Shorter burst duration is more interference-free, but requires the use of several parallel carriers and spreading of the power available among them.

Bit rate capacity

To transmit data, the RCTT modulates carriers of a burst structure using a 4-QAM, 16-QAM or 64-QAM constellation protected by forward error coding rate of 1/2 or 3/4. Such constellations consist of 2 burst structures, 3 carrier spacing modes and 4 possible guard intervals. They typically provide the DVB-RCT system with a net bit-rate per carrier ranging from 0.6 kbit/s to 15 kbit/s. When all carriers are used, the BS is able to collect from 1 Mbit/s to 30 Mbit/s of user data from the DVB-RCT channel.

The most robust modes offer the lowest bit-rate over a large radius cell, while the weakest modes offer the largest bit-rate over a small radius cell.

Dynamically assignable adaptive modulation

DVB-RCT supports the simultaneous use of different types of modulation in the same cell. This feature, called dynamically assignable adaptive modulation, enables a service provider to control the level of interference from a given cell with neighbouring co-channel cells while, at the same time, providing the maximum bit rate to each user.

DVB-RCT coverage with fixed roof-top antennas

Even with the limited power of 1 W (30 dBm) the upstream DVB-RCT transmission cell replies to the downstream DVB-T distribution one. The DVB-RCT receiver is also able to demodulate a weak DVB-RCT signal even when located in a TV transmission site radiating kilowatts of TV signals.

DVB-RCT services can be provided wherever a DVB-T signal is available and even in a saturated spectrum environment DVB-RCT reception remains possible.

Even at borders of a DVB-T service area (up to 80 km from the DVB-T downstream source), successful DVB-RCT return transmission is possible with a transmitting power of 15 to 20 dBm, which is far below the 30 dBm maximum power level.

DVB-RCT coverage with indoor antennas

- The system operates successfully without requiring more than 20 dBm DVB-RCT power. Usually, the attenuation from outdoor to indoor transmission is about 9 to 12 dB and it does not compromize the DVB-RCT suitability;
- After a 95 dB amplification a weak signal from an “indoor” DVB-RCT terminal may be retransmitted successfully to a distant base station.

DVB-RCT is the best available solution offering a wireless interaction channel for real-time interactive digital terrestrial television services for the following reasons:

- DVB-RCT is spectrum-efficient, low-cost, powerful and it provides a flexible wireless multiple access OFDM system;
- DVB-RCT can service large cells (with up to 65 km radius), providing a typical bit-rate capacity of several kilobits per second for every TV viewer;
- DVB-RCT can handle very high peaks in traffic, as it has been specifically designed to process up to 20 000 short interactions per second in each sector of each cell;
- DVB-RCT can be used with smaller cells to create denser networks of up to 3.5 km-radius cells giving the user a several megabits-per-second bit-rate capacity;
- DVB-RCT has been designed to utilize any gaps or under-utilized spectrum anywhere in Bands III, IV and V without interfering with the primary analogue and digital broadcasting services;
- DVB-RCT is able to service portable devices, bringing interactivity wherever a terrestrial digital broadcast signal is receivable;
- DVB-RCT can be deployed globally, although different DVB-T systems (6, 7 or 8 MHz channels) are now in use;
- DVB-RCT does not require more than 1 W (30 dBm) power for transmission from a user terminal or STB to a base station.

NOTE – DVB-RCT is under study by ITU-R Study Group 6.

- **Organization of terrestrial digital broadcasting return channels using cable TV broadcasting technologies**

The most important problem in creating interactive terrestrial digital TV broadcasting networks is organizing the return channel.

This problem is solved in the easiest way in cable TV broadcasting systems. The questions of creating interactive digital TV broadcasting channels nowadays have been studied from the technical point of view in the most detailed way exactly as applied to cable means. But for developing countries, using cable networks for both digital TV broadcasting as such (downstream) and organizing return channels for terrestrial digital TV broadcasting (upstream) is not always viable (primarily for non availability). To organize return channels that provide fully fledged interactivity one needs new generation cable networks that are based on HFC technologies. The viability of organizing return channels for digital TV broadcasting on the basis of existing analogue cable TV networks seems doubtful and lacking in prospects from the technical point of view. And laying fibre-optic cables in order to organize new generation networks calls for substantial initial investments. Furthermore, in some parts of cities laying new cables is altogether impossible due to specificities of the local relief or reasons not connected to the technical aspects of the problem. Naturally, organizing the return channel is possible on the PSTN basis, but in contrast to broadcasting systems PSTN systems are not omnipresent. Furthermore, in this case the user would have to buy interactive digital TV broadcasting services from two providers instead of a single one, with all ensuing negative economic consequences.

As a result of this, with reference to problems in organizing the return channel for terrestrial digital TV broadcasting it is only natural to turn to radio. In particular, one possible option is the use of local multipoint distribution system (LMDS) systems (owing to their broadband characteristics, LMDS systems might also be used for organizing digital TV broadcasting return channels). For such systems ETSI has developed a standard for organizing the return channel (ETSI EN 301 199 V1.2.1 digital video broadcasting (DVB); Interaction channel for local multipoint distribution systems (LMDS), 1999). Formats of data transmitted on the basis of this technology are almost fully compatible with the DVB/DAVIC data format for cable TV networks. But comparatively high transmission frequencies, the necessity to use supplementary user equipment and the complexity of SHF devices with the necessary specifications make this option not too attractive from the commercial viability point of view.

As one of the options for organizing the return channel for terrestrial digital TV broadcasting it seems advisable to consider the possibility of using DVB/DAVIC technology for cable TV systems. Choosing this option gives an opportunity to unify the system with LMDS technologies. Besides, the DVB/DAVIC standard provides for the chance to control by one direct channel up to eight return ones and this might be important for greater loading of a return channel.

Let us consider the possibility of organizing a return channel for terrestrial digital TV broadcasting on the basis of DVB/DAVIC technology put into the air in the Band IV and V frequencies. In dense cities predicting the diffusion of radio signals is a complicated task. But in order to do this use might be made of models and methods that are already developed and are used for designing mobile communication systems and allow estimation of the signal at the reception point with satisfactory accuracy. As applied to user STBs which unlike mobile telephones are stationary devices (we do not deal with questions of mobile reception of digital TV broadcasting signals here), simplified models could be used. This is possible because signal loss along the radio path in a dense city is caused by the attenuation of the signal in the free space and extra losses due to diffraction caused by buildings' roofs. The return channel for interactive TV broadcasting in the Band IV and V frequencies could be organized in two ways. Data transmission along the return channel might be ensured from the user STB itself (the most complicated option here is when the STB is located at ground level). But the transmission might also be ensured by means of a directional antenna installed on the roof of a building.

Organizing the return channel in the air in the Band IV and V frequencies primarily calls for regulating the output power of a user modem's transmitter. In turn, this figure is directly dependent on the area covered by the system. To improve the electromagnetic situation in the air, the output power of a user modem's transmitter should be minimized, but the area covered by the return channel's signal would correspondingly also become smaller. Besides the power of transmission of the user's modem, the return channel efficiency is also determined by the boundary signal/noise ratio of signals transmitted. To extend the coverage area it is desirable to transmit data using small alphabet modulation. The quality of the system is estimated according to BER probability. For example, with inputted Gaussian noise for QPSK modulation we have 11 dB and the BER = 10-6 boundary signal/noise ratio. Let us estimate the possibilities for organizing the return channel in this way from the point of view of signal diffusion specificities. To achieve transmission at 900 MHz with the return channel at 200 kHz (QPSK signal) with 7 dB signal/noise ratio to ensure a coverage of 5 km (we estimate the free space attenuation to be 105.5 dB) 36.7 dB/mW user modem power output is needed. To achieve a larger coverage area, for example 15 km (we estimate the free space attenuation in this case to be 115.1 dB) 36.2 dB/mW user modem power output is needed. Signal attenuation due to diffraction in both cases is taken to be 34 dB. When the 300 MHz band is used to organize the return channel with a 5 km coverage area (the free space attenuation is 96.0 dB), user modem power output should be 23.1 dB/mW and to achieve a 15 km coverage (the free space attenuation is 105.5 dB), user modem power output should be 32.7 dB/mW. Signal attenuation due to diffraction in both cases is taken to be 30 dB.

Thus, when STBs are located at ground level and without any supplementary devices, the output power of the signal transmitted by the user terminal along the terrestrial return channel is comparable to the output power of cellular telephones. But due to the broadband characteristics of the signal transmitted in Bands IV and V, the difference in energy specifications depending on the central frequency of the return channel (900 MHz or 300 MHz) is great enough. The working conditions for the user modem of the return channel in such a mode (when the STB antenna is located below roof level) are comparable to those of mobile communication systems. As STBs are mostly used for stationary reception, we (as it was stated above) do not look here into the questions of receiving digital broadcasting signals and organizing the return channel while on the move.

When it is necessary to achieve a bigger coverage area, the limitations for the value of the user modem output power naturally remain the same, and it may be advisable (as demonstrated above) to organize the return channel using a home distribution network with a directional antenna installed on the roof-top. Using directional antennas in home distribution networks eliminates additional signal attenuation caused by diffraction but also substantially decreases the required output power of user modem's return channel transmission. Furthermore, the number of sources of interfering signals due to multibeam distribution also decreases. This kind of return channel organization makes it possible to use bigger alphabet modulation (e.g. 16-QAM – DOCSIS) in order to increase transmission speed. When transmitting data along the return channel of a home distribution network and antenna installed on the roof, the power required at the antenna's output substantially decreases. The area covered substantially increases. So, when transmitting along a return channel at 900 MHz with 200 kHz as the return channel's frequency band (QPSK signal is being transmitted) and with 7 dB as the STB's signal/noise ratio and the antenna's amplification factor equal to 7 to ensure a 15 km coverage (free space attenuation is equal to 115.1 dB/mW) we need 5.2 dB/mW transmission power at antenna's output. To ensure a 30 km coverage (free space attenuation is equal to 121.1 dB/mW), we need 11.3 dB/mW transmission power at the antenna's output. When transmitting along the return channel a 16-QAM signal to ensure a 15 km coverage we need 9.2 dB/mW transmission power at the antenna's output and to ensure a 30 km coverage we need 15.3 dB/mW transmission power at the antenna's output. The area covered by the return channel would also increase when antinoise coding is used for transmission. But it should also be noted that organizing the return channel for a home distribution network calls for supplementary equipment, thus naturally leading to rising costs for the system.

Another option for creating large information systems with a low output power at the user terminal and large area coverage is the single frequency network (SFN), which can be organized on account of the DVB-T signal protection intervals introduced to prevent multibeam diffusion. Such a network is efficient owing to the difference in reception of direct and reflected beams, equal to the length of one protection interval. Depending on the DVB-T system parameters, creating single frequency networks is possible when the distance between the reception point and the interfering signal source is from 2.1 to 67.2 km. The SFN system structure may be represented as the division of a large coverage area into small zones (cells), each of them having some retransmitting device. Standards for such systems that broadcast in DVB-T format have been developed by ETSI (ETSI TS 101 191 V1.3.1 digital video broadcasting (DVB); DVB mega-frame for single frequency network (SFN) synchronization, 2001) and they call for inbuilding of synchronizing data into the MPEG stream. The signal at the transmission point is being demultiplexed, synchronized and then remodulated. Signals are carried to the base station by some distributional system (e.g. fibre optic).

Such a way of organizing the return channel for digital TV broadcasting decreases the requirements for the power of return channel transmitters. The area covered by the system is determined by the length of the DVB-T signal protection intervals. To ensure compatibility between signals in different "cells" it is possible to use frequency division of channels. Still, it should be noted that using supplementary low-frequency signal processing substantially complicates the system as it requires the installation of supplementary receiving and transmitting stations (analogous to base stations in cellular communications). Thus, creating single frequency networks is similar to organizing cellular communication systems. The former therefore have all the advantages and disadvantages of the latter. On average, with high data transmission speeds, the circumstances described give sufficient reason to believe that interactive digital TV broadcasting networks would be highly competitive.

2.5.3 New emerging technologies

The emergence of electronic communication markets, where the traditional distinctions between broadcasting and telecommunications are becoming increasingly blurred, calls into question the logic of maintaining the existing separate regulatory frameworks for telecommunications and broadcasting. The integration of frameworks, however, is not simple and requires more than the creation of a single regulatory body. It requires a review of the legal and policy frameworks covering the formerly distinct sectors and the creation of a single policy framework which is coherent across the electronic communications sector. New platforms, in particular broadband internet, and the services provided on these platforms will begin to compete with traditional services provided over broadcasting and telecommunication infrastructures. This also provides a challenge to regulation. New developments do not imply that existing regulations need to extend their coverage over other platforms or services. Rather, they offer an opportunity to review and lighten existing regulations.

Policy and regulatory frameworks have already changed significantly for the telecommunication sector over the last five years in many countries. Although significant changes have taken place in the broadcasting environment as a result of digitization, the emergence of digital television, the increasing impact of internet audiovisual services and convergence at the technological and service levels, the emphasis on changing frameworks has not been as pronounced as for telecommunications.

Digital technologies and the diffusion of new transmission technologies have increased the number of platforms capable of providing video transmission. They have also altered the traditional characteristics of broadcasting, such as lack of interactivity and the concept of broadcasting as a "one-to-many service". These changes have implications for broadcasting regulation and, in particular, criteria and methods for licensing market entry. The regulation of broadcasting has covered a number of key areas. The government has decided on the number of market players, provided the individual licences to players and determined their service offerings through a range of licence conditions and regulations. Governments have traditionally determined the number of broadcast licences based on spectrum, but this has become less of a constraint as a result of digitization and compression technologies, while the range of technologies capable of providing "broadcasting" or "webcasting" to households implies that arguments on the social impact of broadcasting (and thus the need to regulate) are less compelling.

The development of digital television allows for a substantial increase in market entry, and therefore potential competition in the market. The possibility to have a larger number and a wider range of players will provide more diverse and innovative services than in the age of analogue terrestrial broadcasting. The introduction of more competition, and the development of new services in converged markets, will require changes in the existing broadcasting regulatory framework. In addition, convergence brings into question the tradition of combining two different sets of regulations with quite a different scope: that is, regulations relating to spectrum management and regulations to meet certain social objectives such as developing national identity and cultural diversity. Fragmentation in the regulation of the broadcasting and telecommunication sectors is not suitable if a coherent and flexible framework is to be ensured to respond to the convergence of broadcasting and telecommunications.

Horizontal coordination is especially important in the field of spectrum management and carriage regulation in order to establish efficient resource management, avoid market distortion and improve competition between infrastructures. Content deployment may need to remain linked to infrastructure regulation.

2.5.3.1 WiMAX

The WiMAX (Worldwide Interoperability for Microwave Access) Forum is a non-profit trade organization, founded in April 2002 by leading vendors of wireless access equipment and telecommunication components. Its mission is to lay the groundwork for an industry-wide acceptance and implementation of the IEEE 802.16 and ETSI HiperMAN standards, namely OFDM (256 FFT) mode, covering the 2-11 GHz bands. WiMAX may enable the BWA industry, by establishing rigorous definitions for testing and certifying products for interoperability compliance.

Information on WiMAX can be found at: www.wimaxforum.org

2.5.3.2 Video-telephony on fixed public network

From June 2004, an Italian operator has offered a new service: by means of a new telephone set including a small TV screen associated with a camera, the fixed network public subscriber can listen to and see his/her interlocutor without using a PC. The goal of this operator is, within 3 years, to supply this equipment to 9 million subscribers, which represents 33 per cent of all the Italian fixed public subscribers.

This new technology is based on a compression algorithm allowing the transmission of a video message on the regular lines at 56 kbit/s. The reception screen is 4 inches, with 64 000 colours. The subscriber can switch off the camera. The technology used does not require an ISDN or ADSL broadband subscriber connection; transmission is only over the public lines.

At first, this service is available only to the operator's subscribers. However, the operator envisages videocommunication with other subscribers with mobile phones or subscribers with a PC webcam link. Moreover, the Italian operator is studying the interconnection possibilities with other national operators.

NOTE – This new service could be available in France and Germany in 2005.

2.5.3.3 Video on ADSL

The first step allowing video transmission on ADSL was the capability of the ADSL network to assume also the load increase generated by the data carried by television. TV needs a transfer rate from 3 up to 4 Mbit/s, in comparison with ADSL where the maximum speed is 1 024 Mbit/s. The video transmission is made according to a coding that is different to the internet data coding: there is no interference; the coding adopted is MPEG-2, and the received information is processed by a decoder (apart from or integrated in the ADSL modem) and sent direct to the TV set. The system requires the public switching multiplexers (DSLM) to be equipped with a component dedicated to the video on ADSL. At the subscriber's home, there is no change or additional equipment (no modifications to filters or connections). The maximum distance between public switching and the subscriber is identical to internet ADSL, in the order of 3 km.

NOTE – ITU-T Recommendation G.993.1 is a new global standard allowing the provision of very high speed digital subscriber lines and multi-megabit network access via ordinary telephone lines, making it possible to offer multiple high-quality digital video streams, high speed internet access and voice.

2.5.3.4 Fibre optics

A new standard for a new optical fibre that will make it easier for network operators to deploy bandwidth to maximize technology in care networks was adopted by MD-T (SG) in April 2004: ITU-T Recommendation G.656.

This recommendation will make it easier to deploy coarse wave division multiplexing (CWDM) in metropolitan areas and increase the capacity of fibre in dense wave division multiplexing (DVDM) systems. Wave division multiplexing (WDM) increases the data carrying capacity of an optical fibre by allowing simultaneous operation at more than one wavelength.

ITU-T Recommendation G.656 allows operators using CWDM to deploy systems without the need to compensate for chromatic dispersion, a phenomenon that at low levels counteracts distortion, but at high levels can make a signal unusable. Although complicated, the management of chromatic dispersion is crucial as the number of wavelengths used in WDM systems increases.

CWDM means:

- Cost affective applications through a combination of uncooled single mode lasers, relaxed laser wavelength tolerances and wide pass-band filters;
- 90 km reach for 2 bi-directional channels at 1.25 Gbits/s on a single fibre;
- 55 km reach for 8 wavelengths at 2.5 Gbits/s;
- 42 km reach for 8 bi-directional channels at 1.25 Gbits/s on a single (conventional) fibre;
- 42 km reach for 16 wavelengths at 2.5 Gbits/s using low water peak fibre.

ITU-T related Recommendations

G 652 Characteristics of a single-mode optical fibre and cable

G 694 Spectral grids for WDM applications: CWDM wavelength grid

G 695 Optical interfaces for coarse wavelength division multiplexing applications

The recommendation also means that at least 40 more channels can be added to DWDM systems. In this case, chromatic dispersion is used to control harmful interference over this – unprecedented – range of the optical spectrum.

All optical networks will allow service providers to deliver applications such as video-on-demand, streamed video on-line games and VoIP. With passive optical networks (PONs), signals are carried by lasers and sent to their destination without the need for active electronics. By eliminating the dependence on expensive active network elements, carriers can realize significant savings. PON technology is used in the local loop to connect end-user premises in an all-fibre network.

2.5.3.5 DRM evolution

DRM is a flexible and open standard that has been designed to fit with the AM bands (LW, MW, SM and new vertical incidence in SW). However, as during the transition period the DRM features will be implemented in receivers with the digital capability along with the historical FM and AM analogue radio bands, some manufactors, industrials, broadcasters and network operators have decided to apply the DRM standard system in the VHF bands (Bands I and II). The benefit for the listener will be radio able to receive digital signals in all the historical AM and FM radio bands, meaning the same level of complexity for the chipset and a lower price for the consumer equipment, addressing a larger market than digital AM only.

2.5.3.6 Hybrid radio systems

a) In the United States, two hybrid systems (terrestrial and satellite) have been launched: XM Radio and SIRIU. Both are based on the same concept. In a large country with a high concentration of the people in urban areas and very few people outside the big towns, it is more cost-effective to use a broadcasting satellite over the country and terrestrial broadcasting in the denser areas where the satellite signal cannot penetrate (high buildings, towers, etc.) everywhere and allow portable and mobile reception. Coverage is thus ensured by terrestrial repeaters. The economy of the systems is based on subscription. In order to be attractive to the listener, new cars are equipped with an embedded receiver and the first year subscription is included in the price of the car; the second year, a fee is payable.

b) In Europe, the DMB system is promoted by satellite company in order to deliver a hybrid system (satellite + terrestrial) benefiting from the complementarities of both media.

2.5.3.7 DVB-H

The merger of audiovisual and telecommunication services has already started, as most telecommunication actors envisage having TV over xDSL. No doubt the user will soon require the associated service environment to be available on the move. Services can be expected to benefit from a window of opportunity of 8-15 years (eight years is the approximate time frame from now until analogue TV simulcast is turned off in most countries, while 10-15 years is the time before new radio systems, whose requirements are currently being discussed under the label “4G”, are rolled out-assuming it will take ten years for 3G to reach break-even point). The opportunity comes from the fact that cellular associated with DVB-T/H would potentially have some of the expected 4G capabilities.

At the basis for the commercial provision of convergent services in mobility, particularly use is made of the DVB-T/DVB-H standard and the concept of wireless communication networks (GPRS, UMTS) combined with terrestrial DVB broadcast networks.

In the new business and regulatory environment, the longer-term activities of various international work-groups such as DVB and 3GPP have slowed down as industry searches for a shorter-term return on investment. The project will bridge this recent trend with the latest technological developments, allowing DVB in particular to keep its worldwide domination as a broadcasting standard toolbox by supporting the design and testing of the DVB-H standard that is necessary because DVB-T is presently being challenged by ISDB-T in mobility and power consumption issues.

Building and validating an open and scalable network architecture

The interworking points between the different domains and actors will also be identified with the objective of defining interworking units whenever required. System engineering rules will be articulated in order to cope with scalability issues. This in particular requires identifying the parameters that are key when scaling up the system. This is crucial to allow the successful progressive introduction of open systems with distributed management functions.

Field trials that include testing of an open operational architecture composed of several broadcast cells will give final input on the viability of the overall system. The novelty will consist in having an open demonstrator addressing the complete/commercial-like architecture. Roaming will be tested between different partners' sites, for instance. Feedback from a panel of users will determine whether the services have sufficiently user-friendly interfaces and will qualify the technical and commercial viability of the services.

2.5.3.8 MPEG-2 to MPEG-4 Migration Aspects

MPEG-2 coding has been normalized in 1992 and from 1995, manufacturers product equipments with this standard. To day, this standard is used by many satellite operators: relevant improvement involves a change process.

The MPEG-4 AVC, later on named only MPEG-4, has been normalized in 2004 autumn in the DVB framework; the decoding structure defines and set. This coding involves a double-performance with regard to MPEG-2 towards the end of 2006. Today, worldwide manufacturers work in wide – spreading R & D programs at the specialized integrated circuits reastement about MPEG-4 coding and relevant decoding; in a word, automated decoding of the broadcasting streams MPEG-2 as well as MPEG-4. It is forecasted to find in the market these multistandard decoders at the end of 2005 with a performance ratio MPEG-4 / MPEG-2 +1.30. The MPEG-4 should be allowed in 2006 for a given audiovisual program process with twice less than binary consumption (or digital busy band). These performances are independent of the broadcasting support; cable, spectrum or ADSL.

Moreover, taking into account the DVB-H standard, the MPEG-4 is particularly adapted with the mobile broadcasting type: today, the MPEG-4 is the alone coding system used for experimentations in Korea, Japan, Germany and Finland.

According to the main actors involved in the MPEG-4 development, the following table gives the MPEG-4 evolution:

Necessary Rate	End 2004	Mar 2005	Sept 2005	2S 2006	2S 2007
HD-MPEG-2	12-18 Mbit/s	12-18 Mbit/s	12-18 Mbit/s	12-18 Mbit/s	12-18 Mbit/s
HD-MPEG-4	8.4-12.6 Mbit/s	8.4-12.6 Mbit/s	8.4-12.6 Mbit/s	6.0-9.0 Mbit/s	5.0-7.6 Mbit/s
Decoders performance improvement					
SD-MPEG-4/ SD-MPEG-2	30 %	30 %	30 %	50 %	58 %
HD-MPEG-4/ HD-MPEG-2	30 %	30 %	30 %	50 %	58 %

2.5.3.9 IMT-2000/UMTS/GSM and DVB-T Convergence

The ad hoc group DVB- IMT-2000/UMTS/GPRS/GSM has classified the co-operation of DVB-T and IMT-2000/UMTS/GSM/GPRS for commercial applications in different scenarios. This classification typically uses the broadcast channel for the down-load (unidirectional way), and the tlc channel (PSTN, xDSL, GSM, GPRS, IMT-2000/UMTS, and…) for the up/down-load (unidirectional/bi-directional way). Particularly addressed are the user views for services built on Telco/Broadcast convergence.

There are many scenarios that can be considered for a co-coordinated use of IMT-2000/UMTS/GPRS/GSM and DVB networks. These range from the simple sharing of content to the sharing of spectrum. A basic assumption for a co-operation of mobile network is that terminals are able to access both networks (DVB and IMT-2000/UMTS/GPRS/GSM). Such a co-operation of both networks will improve the capabilities and varieties of services, the economics for the user and, hopefully, the ease of handling. It combines the network service modes of both network and thus enables new solutions for applications. Of course, there will still be services, which need only one network. Some applications like interactive TV can use also separate terminals, e.g. a set top box (IRD) of a IMT-2000/UMTS/GPRS/GSM mobile terminal. Furthermore, the co-operation of networks enables the use of the IMT-2000/UMTS/GPRS/GSM operator's services like customer relationship management and billing for all services.

Initially, the work of DVB- IMT-2000/UMTS/GPRS/GSM group has focused on the provision of services using the DVB-T and IMT-2000/UMTS/GPRS/GSM platforms. The specifications will be developed in different stages, corresponding to the availability of present hardware and software products and the development time required for new solutions mainly:

a) Interactive Broadcast services (video, data); use of IMT-2000/UMTS/GPRS/GSM as a return channel for interactive TV. IMT-2000/UMTS shall be able to substitute GSM as a return channel for these services for dial in access and further for internet-based access.

b) Integration at the terminal level.

   No definitive co-operation of networks is required. The specification covers only the terminal, which is able to switch between the two networks and related services. The user has the choice to select the service of DVB or IMT-2000/UMTS/GPRS/GSM to get requested information

c) Integration at terminal and network levels.

   Co-operation of networks with applications using both co-operating network resources. Terminals are firstly portable PCs, PDAs etc combined with a IMT-2000/UMTS/GPRS/GSM "modem" for interactive services, which run on a co-operative software platform, e.g. in a domestic or car environment. The mobile handset and the broadcast receiver can connect (for example) into the PC via USB ports. The data allocation in the DVB Transport Stream can be used for IP data carousel play out and multicasting/unicasting; IMT-2000/UMTS/GPRS/GSM will operate as an interaction channel for internet services.

d) Mobile operation: full mobility and range of co-operative services within a single handset (terminal). Delivery of DVB content and services over IMT-2000/UMTS/GPRS/GSM will be supported. Content can be delivered via IP over the DVB-T platform, in all or part of the multiplex or (suitably re-purposed) over IMT-2000/UMTS/GPRS/GSM.

The co-operation platform will incorporate all functions that enable inter-working between legacy domains (broadcast, cellular), or new functions that are not available in any legacy domain.

2.5.3.10 LMDS systems

LMDS at 42 GHz is now a mature technology in terrestrial digital video broadcasting with the capability to have a great amount of band to offer services to the customers. For example multichannel LMDS and MPEG-2 compression coding system –allowing multiple digital time-shifted programs inside the same 33 MHz video channel – permit NVOD (Near Video On Demand) services, without any “return connection” between the customer and the Service Provider.

Services with a low interactivity level like Video on Demand (VOD), Games or Home Shopping applications, can be achieved over LMDS with telephone return channel: most of the commercial DVB Set Top Boxes (decoders) already include internal telephone modem. Also internet access with telephone return channel is achievable, deserving some LMDS down-link channels to deliver internet traffic

LMDS technology is rapidly evolving and the introduction of higher levels of interactivity, will move applications from pure entertainment to Wireless Local Loop (WLL) services. In-band return channels offer attractive independence from PSTN (Public Switching Telephone Network) for Services Providers. Interactivity is pushing LMDS and WLL applications into a merge whose continuous technology evolution will contribute extending profitable business penetration.

Some WLL services promise profitable commercial businesses for Small Business of Home Business (SOHO) subscribers; in particular high speed internet surfing seems to be a valuable service for most of the users.

Due to the propagation limitation, line of sight users are mandatory. The target market for Broadband Wireless Access systems could be a single or multi-tenant building within the coverage area of the cell with clear line of sight to the base station, and sufficient traffic volume to economically support the cost of the network infrastructure. There is also the need of a wired building in order to allow the distribution of forward and return channel, needed if an high interactivity level is requested, to each user from the RF terminal on the rooftop.

2.5.3.11 FLO Technology

MediaFLO is an end-to-end solution, that includes a new mobile broadcasting technology and air interface, known as Forward Link Only (FLO) technology. FLO was designed from inception to effectively address key challenges involved in the simultaneous delivery of video and audio content and/or data applications to a large number of handheld devices. These challenges include requirements that address quality of service, data capacity, power consumption, coverage, mobility, and spectrum efficiency. Like many mobile wireless digital broadcasting technologies under development, FLO uses OFDM.

FLO technology is being made available to a non-profit industry association called the FLO Forum for the purpose of bringing a cooperative specification to international standards organizations for consideration and adoption. FLO technology is further described in the ITU-R BT.2049 Report on Broadcasting Multimedia and Data Applications for Mobile Reception.

In the United States, a nationwide MediaFLO network is currently being deployed using the FLO technology. It will operate in a single 6 MHz carrier in the lower 700 MHz broadcast spectrum, specifically 716-722 MHz. The FCC has also defined the 700 MHz technical rules, which allow for the deployment of high power (50 kW ERP) transmitters. The network can deliver up to 100 channels of content, including for example up to 20 live streaming video channels (Quarter Video Graphics Array/QVGA resolution, at up to

30 frames per second), 10 audio live streaming channels, 50 to 80 channels of short format video cashed on mobile device, and numerous data channels. This network will provide nationwide coverage for multimedia services to consumers in cooperation with broadcasters and wireless operators. Commercial operation of the new network is expected in the second half of 2006.

Content Acquisition and Distribution

Both linear real-time programs and "non-real-time" content are received directly from broadcasters and content providers, typically via a C-band satellite in MPEG-2 format respectively from an IP link, utilizing off-the-shelf infrastructure equipment. The content is then redistributed over the FLO network.

Content may consist of high-quality video (H.264 QVGA) and audio (MPEG-4 HE-AAC) as well as IP data streams. An IMT-2000 cellular network, such as 1XEV-DO, UMTS, or HSDPA, is required to provide important control functions to support interactivity and facilitate user authorization to the service.

In addition, FLO air interface enables the application of statistical multiplexing yielding significant gains realized by encoding real-time media under bit control of a statistical multiplexer that allocates bandwidth per service. It also supports quality of service requirements per audiovisual programme allowing different coding rates and modulation for different applications.

Power Consumption Optimization and Channel Acquisition

FLO technology simultaneously optimizes power consumption, frequency diversity, and time diversity. FLO has a unique capability that allows it to access a small fraction of the total signal transmitted without compromising either frequency or time diversity. As a result of these considerations, it is expected that a FLO enabled mobile device can achieve comparable battery life to a conventional cellular phone.

The FLO air interface employs Time Division Multiplexing (TDM) to transmit each content stream at specific intervals within the FLO waveform. The mobile device receiver circuitry only powers up during the time periods in which the desired content stream is transmitted; all other times it is powered down.

FLO technology minimizes program channel acquisition time. In most cases, it is less than two seconds. Mobile users can channel surf with the same ease as they would with digital satellite or cable systems at home.

Wide- and Local-Area Content

FLO systems support the coexistence of local and wide-area coverage within a single Radio Frequency (RF) channel. When utilizing a SFN configuration, it eliminates the need for complex handoffs for coverage areas. The content that is of common interest to all the subscribers in a wide-area network is synchronously transmitted by all of the transmitters. Content of regional or local interest can be carried in a specific market.

Transport Mechanisms

FLO incorporates effective means for transporting packets based on content type. IP is used when IP has a quantifiable advantage such as in the delivery of "non-real-time" content or data (text and graphics) to an IP application.

Real-time streaming media is delivered directly to a sync layer that is designed to minimize the impact of lost packets in streaming media. A primary FLO design objective is to maximize efficiency by eliminating cascading protocols. This results in more capacity being available for media and minimizes power consumption, since receiving fewer total bits conserves power.

Chapter III

Ways of transition from analogue to digital terrestrial broadcasting systems

3.1 Legal and regulatory aspects

3.1.1 Regulatory aspects during the transition

The regional allotment and/or assignment plans are the basis for the channels that are assigned (or allotted) to any administration. Pursuant to the report from RRC-04 to the second session of the Regional Radiocommunication Conference, annexed to Resolution 1, and in particular Chapters 3 and 5 thereof, the transition from analogue to digital broadcasting (video, sound and data) obliges administrations to consider various items.

1) When to introduce digital broadcasting: transition period, parallel use of analogue and digital, or a clear cut?

2) The interaction between the existing analogue and new digital broadcasting technologies.

3) How to use video broadcasting (such as DVB-T) and sound broadcasting (such as T-DAB), as a single or dual service usage throughout the European Band III?

4) Which of the existing and planned assignments should be protected during the transition period?

5) Coordination and notification processes for the broadcasting (analogue and digital) and other existing stations.

Video broadcasting is mainly received at home, while audio broadcasting is mainly received in mobile. If the digital video is strong enough, it will be received indoors and in trains and buses. Video broadcasting is transported to the viewer via terrestrial, satellite, cable, cellular and even ADSL emissions. Digital broadcasting requires digital receivers; in addition, if the signals are low, citizens will also need new antenna installations.

Terrestrial-borne video has many national advantages over satellite, including: sovereignty as regards transmitters, more immunity to interference, better interactivity, simpler reception. However, most video viewers may be reached by wired communications, thus saving the frequencies for other services, such as mobile.

Administrations can leave the solution of digital terrestrial reception to the free market; however, in many countries the broadcasting operator is forced to provide a national terrestrial off-air coverage. In such common cases, administrations may subsidize (for those who cannot afford) set-top boxes, to fit existing TVs for digital reception.

3.1.2 Regulatory framework

The telecommunications law determines the regulatory framework of all telecommunications, including digital broadcasting. Examples of such laws are: the 1998 Wireless Telegraphy Act in the United Kingdom, 1996 Telecommunications Act in France and 1996 Communications Act in the United States. The regulation of digital broadcasting is prepared by the administration, and the standards by industry. It is recommended to regulate digital broadcasting at the regional rather than national level.

The introduction of digital broadcasting needs appropriate regulation (preferably light-touch), including as a result of the convergence of:

1) Broadcasting and telecommunications. The migration from analogue to digital affects the main multimedia service providers. Digital broadcasting provides interactivity and triple play (video/audio/data). It competes with the cable TV and satellite broadcasting services. Such competition may reduce prices and improve quality of service.
2) Transport and content, i.e. is the internet a telecommunication or information service?

Such issues may require organizational changes in the administrations to overcome such challenges.

3.1.3 One global standard versus different standards

One aspect to be regulated is the digital broadcasting method. The country has to decide on one standard only, within its territory. It is favourable to use the same standard as neighbouring countries, in order to improve compatibility and coexistence.

Regarding television, the United States (and Canada) adopted ATSC[1], Europe (and Russia) DVB-T[2] and Japan ISDB-T[3]; China and India have not decided yet. The different standards are not compatible. This is reminiscent of the analogue TV experience, with the American NTSC versus the European SECAM and PAL systems. With no worldwide standard there is no compatibility.

The main advantages of various standards are competition among methods and innovation; the advantages of a single standard are interoperability, roaming, economy of scale and less RF sharing issues. A harmonized top-down standard provides worldwide interoperability (and some monopoly); the GSM success provides the advantages of centralization (such as roaming). Bottom-up standards offer pluralism, competition and spread the risks (if one method fails).

In the case of digital broadcasting, competition between standards will not lower prices, as a single standard provides economy of scale.

The following table describes the benefits of one or various standards:

Table 5 – Advantages of one worldwide standard or various

	Policy	Regulation	Network services
Worldwide standard	Harmonization	Interoperability and roaming; compatibility	Economy of scale
Different standards	Competition; innovation; pluralism	Non-intervention; the best will win	Free market; spread risks

1 The Advanced Television Systems Committee.

2 Digital Video Broadcasting – terrestrial.

3 Integrated Services Digital Broadcasting.

3.2 Technical aspects

3.2.1 Methods of implementing digital terrestrial radio

Radio broadcasting is an area in which digitization, with its technologies employing coding algorithms for sounds and even images, its set to develop. Digital radio should ultimately replace today's analogue terrestrial network, thereby optimizing the use of spectrum and bandwidth resources. The use of digital technologies will produce far-reaching changes in terrestrial radio. It will give the majority of listeners' access to a broader array of programmes and new services and to better quality radio. Besides improved audio quality, it will allow the development of new services such as advanced traffic information, personal information channel, distance learning, etc.

In order to receive digital radio the listener need new receivers. These receivers could be dedicated to a specific standard or combine two or more different digital radio standards depending on the region or area (for example, in several European countries it could be a combination of DRM and T-DAB). For a number of years, until the switch-off of analogue radio, the receivers will probably be able to receive both analogue and digital radio.

Digital terrestrial radio will probably remain for years a free to air service. As an example, in a lot of areas of the world listeners have been listening to their preferred radio stations free of charge for 80 years. Only very specific services will be based on subscription and/or pay services.

In an audiovisual landscape where numerous new digital radio standards are introduced, the laws, regulatory body, broadcasters, network operators and product manufacturers have to chose the appropriate and complementary standards fitting the frequency allocations, structure of the networks (international, national, regional and local services) and content providers.

Broadcasting

In order to launch digital radio, work has to be done on the transmission sites. The deployment of digital radio nationwide means the upgrade of existing transmission sites by either introducing new transmitters and/or upgrading the existing transmitter (for example, analogue PSM and PDM transmitters upgraded as DRM transmitters). The contributing network has also to be upgraded in order to feed the transmitters with the best possible compressed audio quality with the associated data.

The broadcasters have to define their strategy to introduce the new digital radio. Choice of a full digital standard has to be made, for example for SFN (single frequency network) for nationwide services or MFN (multi-frequency network) to introduce regional and/or local services.

Concerning digital AM systems, broadcasters in agreement with the government and regulators have to choose either to introduce the system based on a multichannel simulcast or a single channel simulcast approach during the transition period. Moreover, broadcasters must remember that with digital there is no longer a border between AM frequencies; according to the service they want to provide, they have to choose the most appropriate frequencies:

Example: Continental, national: HF
National, regional, local: LF, MF
Local coverage: HF in 26 MHz bands

Quality of service

Introducing digital techniques in radio networks allows the provision of new methods to measure the end-to-end quality of service (QoS) in the coverage area by spreading a few receivers. If he has an agreement with a network test provider, he can check that the service provided by the network operator fits the level of quality defined in the commercial agreement. In the country, the network operator can check that the transport stream delivered by the broadcaster is in compliance with the elected standard.

In digital HF, it is possible to have an automatic analysis tool which measures the quality of service in the targeted area and can even manage an automatic feedback loop (exciter, transmitter, antenna, propagation, channel and reception conditions). QSAM, a European project within the framework of the 6th framework, has permitted several partners to validate the dynamic feedback loop using up to 5 different reference receivers pooled by an analyser remote-controlling different transmitters. The longest distance transmitter was located in Bonaire (Antilles) and was targeting western Europe over more than 6 000 km.

Contents

The digitization of radio broadcasting allows the introduction of new attractive content benefiting from the "multimedia" capability of digital radio broadcasting (sound, data and even pictures). One example of the exploitation of T-DAB access in the United Kingdom is the introduction of fully new and attractive content. The duplication of existing content with only an improvement of the audio validity is not enough. Another example is the digitization of SW broadcasting, which allows the broadcast of music, which was not possible in the past with analogue SW. Only in perfect propagation conditions was the audio sound acceptable; most of the time it was too weak.

The capability, by adopting flexible standards, is to provide multilingual content and deliver the main service with, in parallel, a personal audio information channel (news, stock exchange, etc.) or traffic information.

3.2.1.1 Digital sound broadcasting (DRM example)

a) Introduction

AM digital broadcasting in the AM band, known as DRM (Digital Radio Mondiale), is a reality. The DRM system is described in Recommendation ITU-R BS.1514.

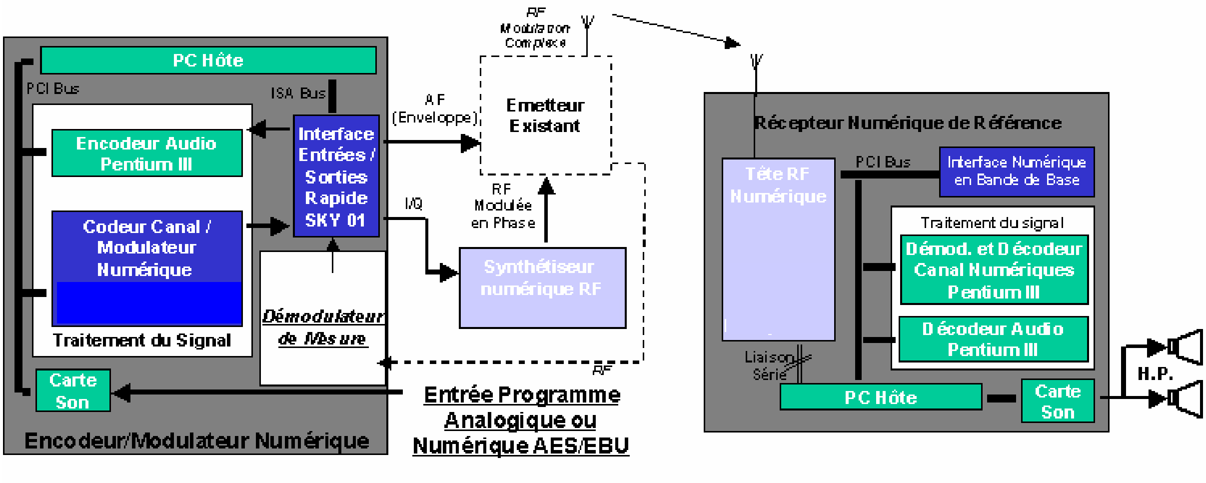
In the face of this emerging technology, radio broadcasters must take stock of the potential market, i.e. listeners' capacity to contribute to the successful introduction of DRM transmitters. To do this, they must set up the technical means of verifying the technical characteristics of the equipment made available to them by the industry without acquiring DRM digital transmitters.

To that end, the DRM Test Kit can be made available to operators, allowing them to test the DRM technology in full-scale field conditions using the existing analogue network. This new approach makes it possible to identify reliable solutions that can be adopted for the introduction of DRM transmitters. The DRM Test Kit meets the operator's needs not only during the period of analogue to digital migration (the experimental phase), but also during the operational phase. What is more, by using the DRM Test Kit with existing analogue transmitters, broadcasters will have in their possession an effective temporary solution until the introduction of transmitters with integrated digital modulators.

b) Description of the DRM Test Kit

Figure 18 below gives a functional synoptic overview of the DRM Test Kit.

Figure 18 – Functional synoptic overview of the DRM Test Kit



b.1 General description

The DRM Test Kit comprises:

a) A digital exciter for a sound broadcasting transmitter, integrated into two industrial computers (PCs), as follows:

- one PC for the digital encoder/modulator comprising a radio interface, audio encoding software, real-time channel coding software, a modulator and a specific modular input-output system;
- one PC for a digital RF synthesizer, providing an enhanced and spectrally pure RF signal modulated with a complex I/Q input signal (where I is the signal phase and Q the phase quadrature). It can deliver either a phase-modulated RF signal or a combined phase and amplitude-modulated signal.

The whole enables an existing transmitter to deliver a DRM broadcasting signal.

b) A digital reference receiver implemented in a fail proof laptop. It includes an LNB, a digital baseband interface, a channel demodulator/decoder, a digital source decoder and a control protocol for the state of the receiver (DRM protocol for TC/SE127 tests).

The digital receiver has integrated real-time analysis functions for the automatic retrieval of those parameters relating to the quality of the signal received and those relating to the propagation channel.

b.2 Digital exciter

The function of the digital exciter for broadcasting transmitters is to process digital signals in real time in accordance with the mode of transmission selected and to deliver compatible signals to the audio input and the RF input of the associated transmitter.

The digital exciter has two main subsystems: the digital RF synthesizer and the system for converting the complex I and Q baseband signal into a phase-modulated or a phase, or amplitude-modulated signal. It is controlled using a digital encoder/modulator via an RS232 connection series.

b.2.1 Digital encoder/modulator

The digital encoder/modulator is used chiefly to process the signal and to calculate amplitude.

Associated parameters, such as the modulator output level (test signal level: 0-3V), the residual carrier level, if necessary (residual carrier: 0-3V), and the test signal frequency (adjustable from – 600 Hz to + 6 000 Hz), can be directly adjusted at the digital encoder/modulator's man/machine interface.

- Audio encoding

Audio encoding is performed by an AES/EBU (Audio Engineering Society CEI958/European Broadcasting Union technical recommendation ITU R68) analogue or digital external audio source using real-time software for the digital processing of the signal implemented on the microprocessor. In addition, the audio source can be generated internally using the host computer's CD reader.

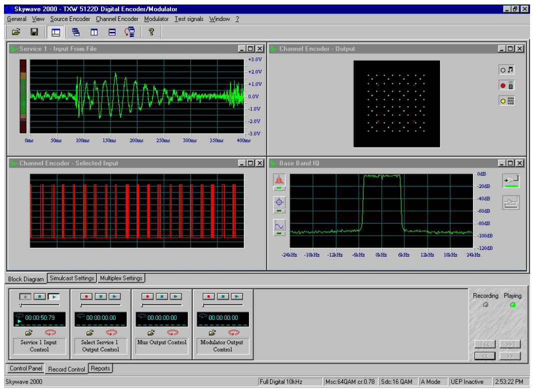
The output data rate of the MPEG-4 AAC (advanced audio coding) audio coder and of the MPEG-4 and MPEG-4 HVXC (harmonic vector excitation coding) speech coders is automatically optimized and adapted to each kind of transmission depending on the choice of frequency band (4.5, 5, 9, 10, 18 or 20 kHz), of the MSC (main stream channel) modulation mode (16-QAM, 64-QAM), of SDC (service description channel) modulation mode (QPSK, 16-QAM) and of propagation mode (Mode A, Mode B, Mode C, Mode D; e.g. ETSI TS 101980). The output data rate can also be manually adjusted to a lower-speed rate. Depending on the rate, MPEG-4 AAC audio encoding can be mono, low-complexity stereo or stereo.

- Channel coding and complex digital modulation

Real-time channel coding and real time complex digital modulation are provided by powerful digital processing of the signal implemented on the host computer's microprocessor and on a special card equipped with four processors.

The digital modulator affords several transmission modes, ranging from standard DSB (double sideband) AM analogue transmission to wholly digital modulation and including simulcast possibilities and specific test sequences for measuring the binary error rate. In addition, specific test signals are available, facilitating the adjustment and technical verification of the associated transmitter during the implementation phase.

Figure 19 – Real-time transmission parameters



- Specific interface module

This module is implemented on a large-size ISA card and provides the interface between the digital encoder/modulator and the associated equipment on one hand and the digital synthesizer feeding the transmitter's RF channel, the audio input, and the envelope signal on the other.

b.2.2 Digital RF synthesizer

The digital RF synthesizer is used to process AM transmitters operating in the 50 kHz to 30 MHz range in the following modulation modes: DSB, SSB and complex digital modulations. It takes the form of a 19-inch 3-unit rack and can operate with analogue or digital modulations. It can be connected to any transmitter equipped with a remote control RS 232 or RS 422 interface. Other interfaces, such as RS 485, 1EEE 488 and 7-digit BCD, can also be incorporated.

When the remote mode is deactivated, the synthesizer can be operated locally using a liquid crystal display and a keyboard for the rapid manual selection of parameters. Local operations are carried out by means of dropdown menus that include a Help function. The synthesizer's operation and maintenance are facilitated by its modular architecture and built-in test equipment (BITE).

The synthesizer comes equipped with a 10 MHz reference input/output (0 dBm, 50 ohms input and 3 dBm, 50 ohms output) for the synchronization of multi-transmitter systems.

The synthesizer accepts digital or analogue input signals for DSB and SSB AM modulation. It also accepts I/Q digital or analogue input signals for digital modulation.

The galvanic isolation of the input, output and interface control signals protects the synthesizer's internal circuits and gives it a high level of noise immunity.

b.3 Digital reference receiver

The digital reference receiver (19-inch rack) is used to demodulate and decode the signal in accordance with the type of signal received. If a digital mode is selected, the digital reference receiver is given online remote instructions using the receiver's automatic reconfiguration symbols transmitted to the kernel. The user can select a real-time detailed view of the signal received at each stage of the digital processing.

The user can record the signal received or replay a prerecorded signal instead of the signal received at certain stages of digital processing. In addition, the digital reference receiver can be used for real-time analysis either directly of the signal received or of a file containing a prerecorded I/Q signal.

The digital reference receiver comes with the following main functions:

- RF demodulation of the signal received is carried out by means of direct digital conversion (DDC) performed by the LNB, which covers all AM frequency bands (LW 153-279 kHz, MW 520 to 1 705 kHz, SW 3 200 to 26.100 kHz).

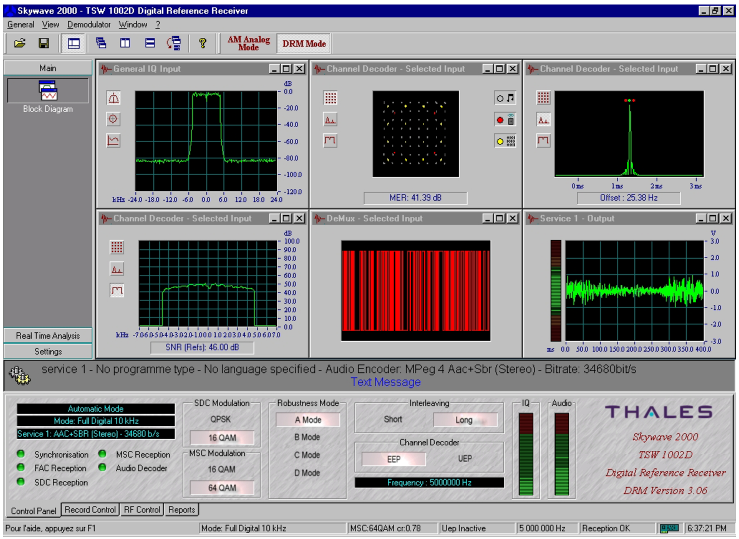
    The LNB's demodulated output signal is delivered in baseband, complex I/Q format, at a sample frequency of 48 kHz, to the digital demodulator and the channel and audio digital decoders via a digital baseband interface.

- The digital baseband interface is implemented on a professional sound card and provides either an analogue input/output or a standardized digital AES/EBU (Audio Engineering Society CEI958/European Broadcasting Union technical recommendation ITU R68) input/output. The baseband I/Q signal received from the RF demodulator is then processed by the digital baseband interface and delivered to the digital demodulator via the host computer's PCI bus.

- Digital demodulation, channel decoding and audio decoding are performed from the baseband complex I/Q signal using real-time signal processing software implemented on the microprocessor.

  The chief transmission parameters, such as spectrum received, channel impulse response, channel frequency response, post-demodulation constellation, etc. are displayed in real time and can be saved on the host computer's hard disk for future analysis.

Figure 20 – Real-time display of transmission parameters



The DRM TC/SE 127 standardized control protocol for the state of the receiver is implemented on the digital reference receiver. It operates over a network link (IP protocol) and can be used to give orders to the digital reference receiver from another computer and to recover all the information provided by the digital reference receiver.

3.2.2 Digital video broadcasting

3.2.2.1 Methods of implementing digital terrestrial television (DTT)

Terrestrial television broadcasting is an area where digitization technology, through the computer coding of images and sounds, is set to develop. Digital terrestrial television (DTT) should ultimately replace the present analogue terrestrial networks, thereby releasing new spectrum resources.

The use of digital technology will produce far-reaching changes in terrestrial television. It will give the majority of viewers access to a broader array of programmes and services and to better quality images and sound. Besides improved picture quality, it will to some extent allow the development of new interactive services (television shopping, games, programme guides). In order to receive DTT, viewers need a decoder, which is either plugged in to sets that receive in analogue mode or integrated within the new digital sets.

DTT may offer both free and pay channels, probably in roughly equal proportions. In an industry where both free uncoded television and pay television are already on offer, DTT, although new, will not amount to an outright revolution. But there will be radical change in that access to free and pay channels alike will inevitably be via a decoder. It is important to note that the attractiveness of DTT will be determined by the extent to which viewers take up uncoded digital channels and that access to encrypted channels must not be tied to access to pay channels.

In an audiovisual environment, which has seen major upheavals in the last 15 years, the development of DTT is an ambitious project. Public authorities should accordingly set themselves the goal of "enabling a public far wider than that of web surfers and pay television subscribers to become familiar with new communication media". Development and diversification of the television programming offered are also awaited in the interests of the greatest number. The advent of DTT is also a new opportunity for allowing public service broadcasting to state its values, for opening up to new content operators and for giving fresh impetus to the programme production industry.

The views expressed by players and future users reveal in general that the launch of DTT is controversial in that this new mode of television broadcasting poses a number of technical and economic problems. Some believe that it is premature and unlikely to be viable, while others take the view that it can succeed subject to the fulfilment of certain conditions. The purpose of this paper is to describe the conditions that will enable viewers' expectations to be met and a secure financial basis to be put in place.

The main aspects of technical preparations for the launch of DTT are outlined below.

- **Broadcasting**

In order to launch DTT, work has to be done on the transmission sites from which it is to be broadcast. The gradual deployment of DTT nationwide means upgrading existing sites currently used to broadcast analogue terrestrial television or building new sites. Existing sites have several components: the land on which they are located, the building in which the television signal is received and the transmitter installed, a mast and aerial system (feeder and antenna). Work is under way continuously in regard to power supply, operation and maintenance.

When a television signal is broadcast from a site, it is picked up from the feeder at the headend, modulated/amplified via a transmitter, then transmitted via an antenna located on a mast or relay tower. When the transmitting antenna is shared by several services (analogue and/or digital), the various components to be broadcast are assembled by means of a radio frequency multiplexer, then transmitted to the antenna by a feeder.

To adapt a site for DTT broadcasting the following measures are necessary of which the first two are the most important:

- Installing radio frequency multiplexers.

- Renewing or adapting mast antennas to accommodate more power or extend the bandwidth in order to bring them into line with existing DVB-T, ASTC, etc. digital standards. Sites should obviously be equipped with new antennas.

- Replacing or reinforcing masts where they are unable to accommodate the additional load.

- Adapting or extending existing sites and buildings to accommodate the new transmitters and headends, or developing new sites if necessary.

- Resizing the energy needed for the new technology (distribution, backup, etc.).

- **Multiplexing**

The multiplex operator plays a special role in DTT: being responsible for the basic physical mix for DTT or headends, it will organize the way programmes “coexist” on a given network (5-6 channels). It will also ensure optimum technical management of the network throughout the broadcast and according to the nature of the programme. The more movements there are in an image, the more space the image needs in the bandwidth.

The multiplexer must therefore effect the necessary tuning and technical adjustments in real time to ensure that viewers have continuous excellent image quality. It will have the choice between static multiplexing (static management of the bandwidth) and statistical multiplexing (dynamic management of the bandwidth according to programme requirements). Optimum band management in the multiplex is particularly crucial for DTT, since interactive services are large consumers of bandwidth.

The multiplexer is located between the source of the television broadcast and the main transmitter which is to broadcast to the viewers’ antennas, possibly via secondary sites. Physically, multiplexers will in theory be installed at a headend, which presupposes developing special areas at or near the site. The likely technical configuration is a national headend, which will in turn be relayed by regional headends for integration of local television programmes.

The multiplexing operation, which ensures signal quality and takes charge of coding, flow multiplexing, transport and dissemination, is an important link in the broadcasting chain and is not unrelated to the choice of channel types, which vary in terms of bandwidth consumption, that will make up the multiplex. The operators will have to conclude contracts with originators for all the technical functions of multiplexing, transport and dissemination. They are the guarantors of all the functions inherent in the broadcasting operation and, in conjunction with the commercial DTT distributor or distributors, must ensure homogeneous development of the coverage of the multiplexes they represent.

Some operators have expressed their interest in taking on multiplexing and are technically prepared to perform the tasks involved. As regards legal arrangements, operators will normally be required by law to have a separate legal identity from originators. In the case of statistical multiplexing in particular, they must abide by the principle of equal treatment for all originators in the same multiplex and observe the regulatory bandwidth allocation. Bit-rate use, technical cost sharing, which must be based on passband consumption, and arrangements for cost-sharing in the event of default by one originator in the multiplex, are matters that will have to be settled in the contracts concluded with originators and according to domestic legislation. Another matter to be considered is whether it might not be desirable for multiplex operators also to be independent of the DTT distributor or distributors.

- **Harmonization and standardization of decoders and access control and interactivity software**

Preparations for the marketing of decoders involve their harmonization. There are different levels of harmonization:

- Harmonization for uncoded programme reception. This has already been achieved, and in the case of terrestrial television, the ITU-R standards have been adopted. Cable operators have drawn the attention of public authorities to the fact that their terminals were not harmonized on the basis of these standards and that any regulation making the latter compulsory would force them to upgrade their entire stock of decoders.

- Harmonization for interactivity access control. The **principle of interoperability** has been established and the technical conditions will have to be defined by regulators.

3.2.2.2 Example – Implementation of a DVB-T network

Faced with digital TV technology, broadcasters should look to the future, and to migration from analogue television services to digital as smoothly as possible. In Europe, for some countries this is important, and the State authorities have decided to stop analogue television at a fixed date.

Broadcasters should assess the market (number of potential viewers), the possibilities for bringing digital TV into service and obviously the incorporation of digital techniques into the existing analogue network. As the first step, the broadcaster should have the technical tools to test digital TV implementation, and to check the technical performances and the quality of service discerned by the viewers.

For these reasons, a minimum equipment package is required for a broadcaster to go from analogue to digital TV. This so-called “digital TV kit” not only allows video and audio services to be put on the air, but it also allows the broadcaster to tune his broadcasting station so that he can obtain the best possible results from his system. As such, the **DIGITAL TV KIT** is the system to use when validating the end-to-end digital technologies and, among other things, when:

- Assessing MPEG-2 encoding performance,

- Assessing the bandwidth saving versus the quality,

- Measuring the capability to cover an area with 1 transmitter,

- Demonstrating the efficiency of DVB-T modulation for home viewers and mobile users.

The DIGITAL TV KIT may also be used by the broadcaster to check the performance of the different set-top boxes available on the market.

As a second step, ENHANCED DIGITAL TV PACKAGES enable the broadcaster to access new value added services:

- Electronic Programme Guide,

- Pay Per View (NVOD – Near-Video on Demand),

- Data broadcasting,

- internet, e-mail, etc.,

- Games, weather forecast, TV shopping, banking, etc.,

and to find the right product to combine adjacent channels and mix analogue/digital channels.

a) Digital TV kit description

To check all the digital TV chain from the headend (production of digital signal) through, eventually, the transport network, to the end-user (viewer), the digital TV kit is made up of:

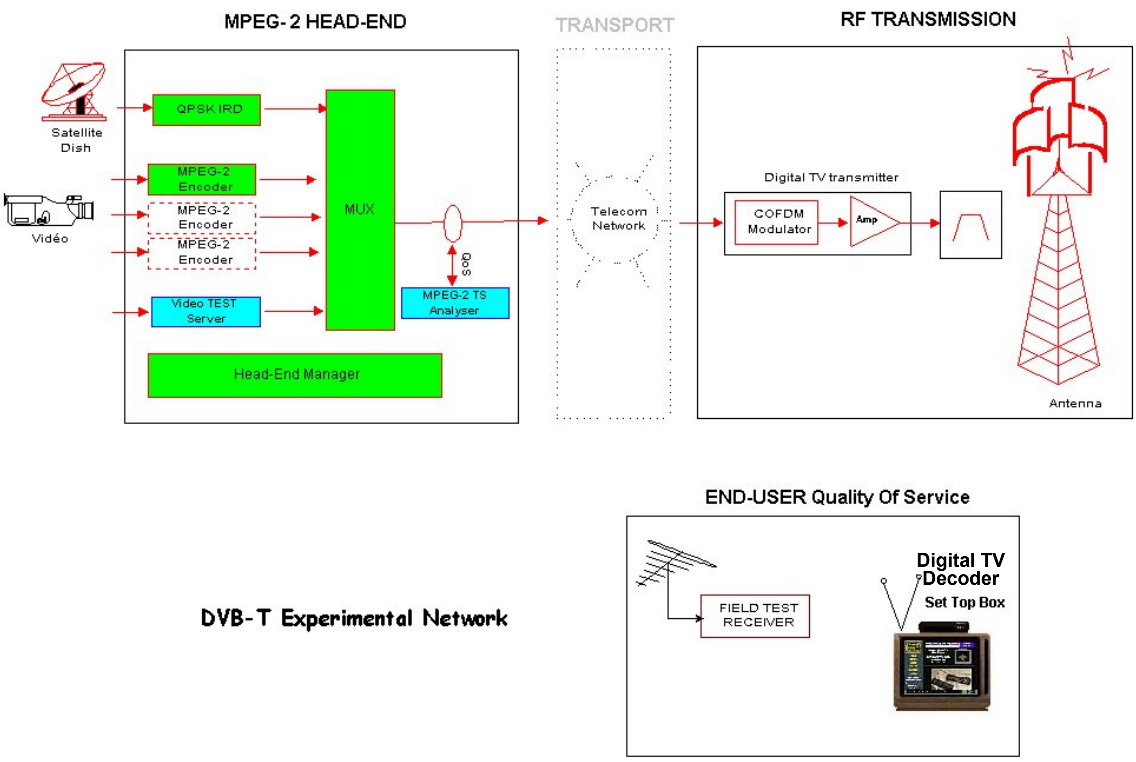
- The headend that handles the MPEG-2 encoding and multiplexing and monitoring,
- The RF transmission that handles the broadcast,
- A set of equipment to assess RF transmission and digital video programme quality at the end-user.

The digital terrestrial network example given hereafter can broadcast a bouquet of 3 audio/video services:

- 1 service provided by the broadcaster and encoded on site.
- 1 service is a national service retrieved from a satellite transponder.
- 1 service is provided by a local video test server.

The digital multiplex is broadcast with a digital transmitter; the signal that feeds the transmitter may be transmitted through a telecommunication network.

Figure 21 – DVB-T Experimental Network



The MPEG-2 headend can be ordered in two parts:

- A ***test platform*** that encompasses an MPEG-2 transport stream player, a transmitter, an MPEG-2 transport analyser and decoder.

- An ***encoding and multiplexing*** *platform* that enables the broadcaster to go a step further towards a fully digital station.

Both can be bundled to obtain an optimal starter terrestrial station.

Test platform

The ***test platform*** is engineered in such a way that a broadcaster can perform a complete range of tests on a minimal and cost-effective platform and is made up of:

Digital video test server

This equipment is an MPEG-2/DVB recording play-back, to generate base-band digital television that can be used to test the DTV transmitter.

The user may select some pre-recorded material or make a real time acquisition from a live MPEG-2-SPTS or MPTS. The user may then play back the recorded material. It provides the ability to broadcast a test signal for validation of the broadcast chain or used as a substitution signal of the failed primary source.

The equipment is based on a client server architecture. The server running on the platform manages data transfers from and to the hard drives located on the platform.

Software clients can be run from the platform or anywhere from the local area network. Each software client takes control of 1 I/O pair at the same time.

Transport stream analyser

The equipment is a unique tool for the monitoring of MPEG-2 transport streams. Its ability to display stream contents and detect errors in real time makes it ideal for use during system installation and testing.

Quality monitoring

This measurement is made possible through transport stream analyser ASI output by means of software implanted in the TV monitor.

Encoding/multiplexing platform

The broadcaster may want to have a minimum platform to broadcast the digital counterpart of his analogue services. The headend may get TV services from several sources: analogue, digital or RF. Thales proposes equipment to cover these three cases.

Once the services are acquired, they are processed according to DVB standard (MPEG-2 encoding, programme descrambling ...), and multiplexed with a single output called a multiprogram transport stream (MPTS) to form a bouquet of services. The multiplexer output is compliant with the DVB-T bit rate and is then RF-broadcast by digital power transmitter.

The encoding and multiplexing platform is made up of the following functional blocks:

DVB-S decoding

The QPSK receiver decoder aims to provide a DVB-compliant transport stream to the MPEG-2 multiplexer.

The satellite receiver demodulates the RF signal in L-band coming from the satellite dish and provides a descrambled TV service to the MPEG-2 multiplexer.

DVB encoding

The MPEG-2 encoders are fed with analogue or digital video and audio signals. They create a single program transport stream (SPTS) fed to the MPEG-2 multiplexer.

DVB multiplexing

The multiplexer provides a customized bouquet of TV services coming from several sources (local MPEG-2 encoders, video server, satellite decoder, etc.).

All services can be scrambled with a specific conditional access system but it is suggested not to use this function within the framework of a trial broadcast station. In fact, several important analyses cannot be performed when services are encrypted; as an example, it is impossible to check the PTS/DTS time stamp coherency when a service is encrypted. Therefore **the output bouquet will not be encrypted**. As a second step, and if the broadcaster goes for the enhancement digital TV package, encryption may be performed.

Headend element manager

The system manager (SM) is a complete system for managing DVB MPEG-2 broadcasting equipment at the satellite uplink site and cable and terrestrial headends. The SM integrates MPEG-2 equipment such as switches, encoders, multiplexers, modulators, ECM and EMM generators, monitoring decoders and PSI/SI inserters from different hardware vendors into one manageable digital TV broadcasting system. The SM server and client application are designed to run on an NT server or an NT workstation.

The SM server application is located on site and executes commands and requests sent from a single or multiple clients. An SM client connects to the SM server locally or via LAN, WAN or through the NT's remote access service. In addition to serving client requests, **the server configures and monitors all the physical equipment in the system**.

The SM client application implements the system's **graphical user interface** (GUI). The GUI framework displays multiple views of the system based on which the operator can monitor and operate the system.

The client application can also be used as a "stand-alone" application to define new systems or to reconfigure an existing system. The operator can connect to the server at a later date and upload these configurations to the server.

b) Transport from headend to transmitter

A network adaptor is used to carry the MPEG-2 transport stream over a physical telecommunication network to the digital transmitter.

Several output interfaces are available: optical, electrical and SDH, PDH or ATM.

c) RF transmission

At this step a digital TV transmitter is implanted, with its power depending on the size of area you intend to cover; it is connected to the existing antenna array. Generally a low-power (200 Wrms) or medium-power (1.25 kWrms) transmitter is used, including a COFDM modulator.

If more than one RF channel is required, it is possible to install an analogue/digital combiner: combiners are used to multiplex two or more RF channels to feed one common antenna system.

d) End-user equipment

An individual COFDM receiver decoder DVB-T receiver is made up of a COFDM 8 MHz front-end in a compact chassis. The receiver is also equipped with an ASI output interface.

Field measurement equipment

The technical assessments are mainly focused on the quality of service achievable in fixed and mobile reception. The quick roll-out of this new service requires measurement equipment that not only allows classical commissioning but also coverage, incoming transport stream analysis and mobile reception.

This equipment should be able to measure different layers present in the DVB-T network:

– Extended frequency range: 5 MHz to 1 000 MHz and selective RF input,
– Input level measurement,
– Modulation analysis: MER, EVM, constellation display,
– Automatic DVB-T parameters measurement: BER, modulations (QPSK, 16-QAM), 2 K and 8 K mode, FEC, etc.,
– Impulse response analysis,
– MPEG-2 outputs SPI and ASI.

Set-top box

After technical assessment with objective measurements, it is also very important to get a subjective quality assessment from a group of viewers. Human vision is the most powerful tool for judging compressed digital picture impairment.

In order to present decoded compressed digital pictures to a group of viewers spread over a reception area, a set of consumer set-top boxes (digital TV decoders) are used with the following equipment:

– Fully MPEG-2/DVB-T compliant with UHF input,
– 2 K and 8 K modes supported,
– Free to air,
– DVB-MHP support,
– Full EPG compliant,
– PAL/SECAM/NTSC video standard.

3.3 Economic aspects

3.3.1 Terrestrial television broadcasting

As regards access to encrypted channels, for commercial reasons and as a precaution against piracy, operators do not all use the same access system, although in the interests of interoperability it would be a good idea for several access systems to be receivable on a simple decoder. Two solutions exist for ensuring interoperability: simulcrypt (interoperability is managed by operators at headends) and multicrypt (interoperability is managed at the terminals). There is also an intermediate solution whereby the decoder is equipped with a standardized interface to which the module and access control card are connected.

Interactivity is a more complex issue and as yet no standard has been established other than an internet-based standard, the other systems being proprietary.

A secure basis for operators

It will be possible for all operators to work from a secure financial basis only if there is an efficient distribution system that affords protection against anti-competitive behaviour

The sections that follow are underpinned by a number of primary objectives: allowing viewers easy access to DTT at reasonable cost; ensuring the viability of originators through a satisfactory return and the holding of costs in check; maintaining the prospect of a return on investment for distributor(s) and preserving it for current cable and satellite operators. There is also a theme common to all the sections, namely avoiding deterioration in the conditions for competition in television markets, particularly pay television, and if possible improving them.

Making DTT attractive to viewers

This means providing easy access at low cost, and offering groups of channels in incremental packages.

Decoders

For DTT to be successfully launched, it must be easy for viewers to procure a decoder with which to receive it. It is equally important that the purchase or rental of a decoder should not be tied to a subscription to pay services. In other words, in devising and managing DTT, the focus must be first and foremost access to the non-pay channels, which for their part will have to engage in a promotional effort. A psychological maximum will have to be set for the price of a basic decoder, as viewers will be put off by decoders that are too expensive.

To be easily accessible, decoders need to be marketed on a large scale, through either general or specialized retailers. It would be a mistake to restrict their sale or rental to pay channel distributors alone. Only large-scale distribution is in a position to give them the broad and visible exposure they need to incite viewers, if not to buy on impulse, at least to think about acquiring such a product, for instance in the context of a DTT information campaign. Too few outlets for the sale or rental of decoders would be a disincentive to the development of free DTT or programming outside the pay-based offering. To confine the marketing of decoders to distributors of pay DTT services would have the added disadvantage of creating or reinforcing manufacturer dependency on the latter, which in the long run could lead to cutbacks in supply or even to some operators being forced out of the market.

Nor should decoders need to be installed by an expert technician: as for any audio equipment or television or computer peripheral (video recorders, DVD players, printers), consumers should be able to connect them to the television set themselves.

Decoders made available to the public should include clear indication on the packaging about their essential characteristics and should be accompanied by an explanatory note on their functionalities. After-sales service would be desirable, and could be provided either by the manufacturer or the vendor, or by both together, so that in the event of a problem consumers can return the product and receive a refund (for example if they have bought a decoder for installation in a place which, unbeknown to them, is outside the DTT coverage area) or call a hotline in order to resolve any technical problems. Specific information on the DTT coverage area should be provided at the sale or rental outlet. Where decoders are rented, with or without a pay channel subscription, the rental contract must be easily terminated and not require too long a notice period.

Marketing

Pay channel distributors must take account of viewers' expectations, within the limitations imposed by the regulators, and use the experiences of cable and satellite as a basis for marketing pay television services. Regulation should contribute to the structuring of the services on offer, in particular by marketing cinema channels separately from other channels.

Opinions on the bundling of services are generally divided, and this partly depends on whether the matter is seen from the standpoint of producers and distributors or that of viewers. Some operators consider that viewers should be given the greatest possible freedom and flexibility by allowing them to choose the channels – or even just a single channel – to which they wish to subscribe. The key to success with consumers, therefore, would lie in the modular nature of the services offered, with easy access to reception equipment and simplicity in subscriptions. Others think, however, that if the services offered are not bundled, this might work to the detriment of new channels or those that are relatively unknown or have low viewer ratings.

Along the same lines, if the same package of DTT pay channels was not made available by a number of distributors, the impossibility for viewers to have access to the full array of services through one distributor could make things so complicated that they might easily give up. If they wanted to have access to the whole array of pay television services, they would have to take out more than one subscription, thereby probably paying more than if they had had a subscription for a single package of channels, perhaps leaving aside the case of the premium channels. Such a scenario could hamper the development of pay DTT, and this might have repercussions on DTT as a whole.

A secure financial basis for originators

A secure financial basis for originators depends on the key elements of broadcasting costs, programme costs, advertising income and revenue from pay channels. The relative importance of these elements varies for established channels and new entrants. In addition, what constitutes a secure financial basis will vary for free-to-view channels and pay channels because of the different ways in which they are funded.

Broadcasting costs

This is a key concern for operators, which stress the high cost of DTT broadcasting – five or six times higher than cable or satellite broadcasting costs.

Even though leading general-interest channels are able to absorb DTT broadcasting costs, which, although much lower than those of analogue terrestrial broadcasting, would be an additional item to the latter, other channels, in particular new ones, whether free-to-view or pay channels, and thematic speciality channels, would doubtless face greater difficulties. This problem is especially crucial for mid-size channels during the start-up phase when revenue (from advertising or subscriptions) is difficult to assess. A number of solutions are proposed by operators to make the launch of channels, especially smaller ones, easier and less risky, and to reduce costs: these include frequency sharing between two channels and a staggered increase in territorial coverage. However, if such an increase was too slow, it could have a negative impact on the audience of the channels concerned and thus on the level of advertising income. At the time it was launched, DTT in the United Kingdom covered between 50 and 70 per cent of the population on a multiplexing basis. Today nearly all multiplex systems have coverage equal to 90 per cent of the population but the low quality of signal transmission means that DTT customers are being steadily lost to satellite channels. In Sweden the public broadcasting operator, Teracom, has set a target of achieving 98 per cent coverage of the population in 2002.

Advertising income

It is difficult to predict developments in the advertising market and changes are closely linked to the economic situation. Television channels show heavy concentrations of advertising investment and inflated tariffs which militate against smaller advertisers.

Hence the advent of DTT might, according to certain analysts, lead to an expansion in the number of channels enabling new advertisers to have access to this advertising medium, mainly at peak viewing times, in particular because of reduced market entry costs. It would also enable advertisers to have advertising strategies geared to the thematic channels.

As regards the new DTT channels, the new advertising revenue will only materialize if they have viewer ratings which advertisers consider significant. This implies DTT getting an effective foothold in the largest possible number of households.

Income from distributor payments

Pay channel originators receive payments from distributors that are mainly based on the number of subscribers. If their programmes were broadcast in parallel in the three modes, originators fear that the fees they receive would drop, as has already been seen for cable and satellite, owing to an imbalanced situation between themselves and commercial distributors. They consider that new DTT subscriber numbers would be insufficient to offset this drop in revenue.

As regards criteria for remuneration, audience figures do not have to form the sole basis. Qualitative criteria, such as subscriber satisfaction and promotion and investment campaigns, may also be taken into account.

A secure financial basis for distributors

Distributors wish to obtain a return on their initial investment within a competitive environment. It is therefore necessary to consider the viewpoint of the various operators concerning the DTT pay-channel package and to evaluate the economic constraints that affect distributors.

Constraints on distributors

Commercial distributors that might become players in the DTT sphere would have to face several types of costs, namely:

- Costs of investment in a stock of interoperable decoders to be made available to the public via sale or rental. The cost depends on the level of sophistication of the device.
- Logistical costs, such as the cost of managing subscribers and terminals, the cost of cards to be inserted in terminals, etc.
- Commercial costs, in particular concerning the promotion of pay-channel packages, especially at the launch of DTT.
- Payments for channel originators.

  Revenue from commercial distributors of DTT would depend on the attractiveness of the channels to be marketed. The overall amount also depends on adequate coverage of the population, competitive pricing of pay-channel packages in comparison with cable and satellite deals, and a promotion policy to ensure a rapid launch of DTT.

  It will be for the regulators to align the marketing of the services offered with multiplexing structures to ensure complete uniformity of the available services throughout the areas covered by DTT.

The distribution system must be compatible with competition law by ensuring the viability of distributors

The ideal DTT distribution system is one in which a large number of distributors, not connected with originators or programme producers, compete with each other to the benefit of consumers/viewers and operate an equitable sharing of revenue between the various players in the value chain to ensure their economic viability. The development of DTT in such a way as to maintain a sound financial basis for all operators in the sector can only be achieved if distribution methods fully comply with competition law. Therefore any distribution system involving payments for the profit of a sole distributor, already active or even dominant in the pay television sector, should be avoided.

Various scenarios may be envisaged:

a) A sole distributor

The sole distributor model raises issues of economics and competition rules.

In economic terms, it is uncertain that having a sole distributor is the best way to ensure the success of DTT, in particular if this distributor is already a player in the pay television market. Indeed, by modulating the dynamism behind DTT marketing, i.e. by limiting efforts to promote DTT or by focusing on its own channels, a sole distributor may hamper the development of DTT. It might also be tempted to retain its leadership in the pay television market, or in one or more segments (cable, satellite, decoders, etc.), if it already occupies a strong position.

In legal terms, the sole distributor scenario is not ideal for the market if it reinforces a dominant position, with all the risks of abuse that this may entail. If the DTT distribution market was to be considered a specific relevant market in the future, which is not the case today since the relevant market is that of pay television as a whole, the position of a sole distributor would be even more monopolistic.

b) A group distributor

Some operators raise the possibility of setting up a common structure for DTT producers in order to market the pay-channel package using two methods: either the operator with the greatest capacity for distributing DTT becomes a shareholder in order to have control over DTT distribution activities, or an ad hoc structure, a joint venture, controlled by the channels, or an economic interest grouping (EIG), is established.

The degree of autonomy of a joint venture determines how it is analysed in terms of the law on mergers, whether national or community-wide, or in terms of the law on agreements.

In the case of a merged joint enterprise, it would be necessary to have the prior backing of the competition authorities.

If such an enterprise was cooperative in character, the setting up of a group distributor, of which the main DTT market players would be part, would necessitate the authorization of the regulators.

As regards an EIG, the competition authorities would generally examine this form of cooperation with caution, particularly in the light of its purpose and any anti-competitive practice which might result from it.

As in the sole distributor scenario, the question also arises whether provision should be made for guarantees from the distributor to other operators, in the event that members of the joint enterprise or of the EIG were linked to a channel producer.

The competition authorities would therefore have to define these guarantees, which would be likely to comprize some or all the rules finally incorporated into a code of conduct.

c) Several distributors

Despite a limited number of pay channels, some operators consider that a number of commercial DTT distributors proposing the whole array of DTT pay-channel services might coexist and propose varying deals to customers according to their interests or offer packages including cable and satellite channels. (This is the case in Finland, where eight commercial DTT distributors, one specific HTV distributor and a number of cable operators coexist).

d) Conclusions

The analysis undertaken shows that to launch DTT successfully within a reasonable time-frame, the following – not necessarily exhaustive – list of conditions has to be met:

– A balanced assortment of free-to-view and pay television programmes, which is attractive and varied by comparison both with free analogue TV programmes and with cable and satellite programmes, in order to compensate for the small number of channels proposed compared with competing cable and satellite programming.

– Easy access at a reasonable price for the viewer in terms of equipment (decoders, television sets with integrated decoders, adaptation of antennas), to both free channels and pay channels (for which subscription costs must be added to those of decoders and antennas).

– Gradual territorial coverage to allow new free channels and pay channels to reach the break-even point within a reasonable time limit, but sufficient to bring in revenue (in terms of advertising and subscriber numbers) to all operators in the sector and uniform throughout the areas covered.

– A policy for the harmonization (and manufacture) of equipment in time-limits compatible with the launch and growth of DTT as well as ensuring the security of equipment to limit piracy.

– Dynamic distribution and a policy for promoting pay channels and stimulating viewer interest which is sufficiently differentiated from that of cable and satellite networks to avoid undercutting them and to show clearly that this is a complementary array of services and a technological advance in television.

  As regards distribution, the implementation of a code of conduct appears at any rate to be necessary. If there is a sole distributor or a distributor at least occupying a dominant position, apart from the complete legal, financial, accounting and commercial separation of the functions of originator and distributor, the code should contain the following guarantees:

– Distributors should in general ensure that they remunerate channels on the basis of transparent, equitable, objective and non-discriminatory criteria. These criteria should not be based solely on audience figures, otherwise new entrants will be penalized.

– If distributors are linked to channel originators because they form part of the same group, they should also implement a commercial policy (composition and presentation of the services offered, prices, sales of advertising space) and a promotional policy which are totally neutral in relation to any channels that are even indirectly linked to them.

– In addition, in the performance of contracts, distributors should:

  1) Present a group of channels to consumers which avoids bias in favour of channels directly or indirectly linked to them, or which they distribute otherwise, and which can easily be modified by viewers according to their interests. Ensure the neutrality of programme guides.

  2) Promote DTT channels in an equitable and non-discriminatory manner.

  3) Ensure equality of treatment in the marketing of pay television services.

  4) Not oblige originators to accept remuneration geared to what they obtain from cable and satellite ("most favoured nation" clause).

  5) Not tie the sale of DTT pay television services to pay television packages that they also distribute via another broadcasting mode, at a price lower than the sum of both subscriptions, and prohibit any use of DTT subscriber details for the purposes of these other broadcasting modes.

  6) Not include in contracts with originators exclusivity clauses, which could prevent such services from also being distributed via other broadcasting modes or by future DTT distributors which, for example, appear after the initial five-year period.

7) Allow originators to dispatch, with reimbursement of the costs incurred, advertising or promotional correspondence to subscribers, without the latter being able to access files or reconstitute them.

8) Not break distribution contracts unfairly before the authorized expiry date.

9) Make interoperable decoders available to viewers and guarantee them real initialization from the time they are in an area covered.

10) Set sale prices at a level that does not discourage consumers from taking out subscriptions and which is not biased towards distributors that also operate in other segments of pay television.

Consideration might be given to incorporating these rules in contractual agreements between producers and distributors, and regulators would then be responsible for ensuring that these rules are observed.

Finally, as in most countries where DTT has been launched, it would be desirable that the public authorities announce a date for the end of analogue broadcasting. Such an announcement might affirm the irreversible nature of the decision to develop DTT.

The second phase of the RRG-06 will answer part of these conditions for those 117 ITU Member States.

3.3.2 Terrestrial radio broadcasting

For the radio broadcasting transition, it is necessary to consider the following impacts with regard to the economic aspects of digitization of the AM bands.

3.3.2.1 Impact on the contribution network

Due to the high level of compression provided by the MPEG-4 audio encoders, it is possible to use bit rates lower than 63 kbit/s to transfer the audio signal from the studio up to the transmitting site(s). This makes it possible to reduce the cost of the transmission of audio over the telecom network (ISDN, special lines, ADSL, ATM or even satellite).

3.3.2.2 Impact on the transmitting site and cost of operation

It is necessary either to upgrade the AM transmitter to enable it to broadcast a DRM signal compliant with the ITU recommendation (spectrum mask, etc.), and this is possible if the transmitter is a modern one (PSM with IGBT switchers or PDM); or to install a new transmitter fully compliant with DRM and still able to broadcast an analogue AM signal.

Regarding the upgraded transmitter, the minimum investment is the DRM exciter.

The new transmitter includes a DRM-capable exciter.

In HF and MF, the antenna system is able to broadcast a DRM signal. In LF, it is necessary to improve the performance of the antenna system in order for it to be able to have the necessary RF bandwidth capability.

Regarding the cost of operation, as the DRM range medium power is roughly a quarter of the analogue AM power for the same coverage area, it is possible to three quarters of the cost of the transmitter's power supply for a DRM transmission.

A new range of DRM transmitter has been developed by a transmitter manufacturer allowing DRM power up to three quarters of the analogue AM transmitter power. This means that the broadcaster who wants to broadcast a full DRM signal could either purchase a smaller transmitter for the same coverage area, or purchase the same power TX and use the QoSAM feedback loop which measures the quality of service received in the targeted area, computing the trend for the propagation channel and then remote controlling the various parameters of the DRM exciter and even modulating the power of the transmitter in order to guarantee the highest possible audio quality for the listeners on a permanent basis.

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3.3.2.6 Impact on the cost of the receivers

First of all, it is necessary to purchase a DRM-capable receiver.

The first-generation receivers will be more expensive than when large volumes are produced for the mass market.

The difference between a DRM receiver and an analogue AM & FM RDS receiver consists mainly in a better RF front end and a dedicated chipset, which will replace the present ones. The cabinet, loudspeaker, antenna, display and keyboard will remain the same as that of a good receiver. This means that the difference of price will be the difference of price of the chipset.

In the long term, DRM chipset prices will converge, although they may be twice the price today of an FM+RDS chipset.

The price of the electronics should be reduced because the RF front end will soon become a fully digital RF front end (direct sampling of the RF signal), and then be embedded in the DRM chipset.

As very large countries have decided to adopt the DRM standard for their international broadcasting but also for their national market, the number of receivers will increase staggeringly. With the learning curve, and the cost of equipment linked to quantity, high quantities mean low prices. Some examples are very interesting: the price of the first CD player was close to 1 000 EUR, but it is possible now to find low-end equipment at prices lower than 60 EUR. The DVD player has followed the same rule: first prices were over 1 500 EUR, are now are less than 100 EUR.

The price of the DRM receiver will depend on the range of the product:

– high-end receivers will soon cost the same price as today's high-end world receivers,

– low-end receivers, depending on the quantities and the reduction in the price of the chipset, should converge to a price close to that of today's low-end receivers.

There are other possible kinds of receiver:

– PC-based receivers,

– Car receivers,

– Embedded receiver in handheld mobile phones and devices.

Chapter IV

Summary of results of RRC-04

4.1 Introduction

The first session of the Regional Radiocommunication Conference for planning of the digital terrestrial broadcasting service in parts of Regions 1 and 3, in the frequency bands 230 MHz and 470-862 MHz, was held in Geneva from 10 to 28 May 2004.

4.2 Main results

- Agreement on definitions to be used in the future three agreements (the new one and the remaining parts of the Stockholm Agreement (1961) and Geneva Agreement (1989).
- Agreement on propagation prediction methods for the whole planning area covering Europe, including C.I.S excluding Mongolia, Africa, the Arab States and the Islamic Republic of Iran, taking into consideration the special propagation conditions in some areas.
- Agreement on all technical bases and characteristics, covering all the detailed necessary elements (frequency bands, reception modes, antenna gains, polarization, planning criteria, C/N values, etc.) to be used in the planning.
- Agreement on how to protect other primary services (non-broadcasting) existing in the planning area, including protection criteria.
- Agreement on the planning principles and methods to be used in the frequency bands 174-230 MHz and 470-862 MHz, in order to prepare exercises between the two sessions and during the second and last session, if this is agreed by the latter.
- Agreement on the formats and their contents for administrations to present their requirements for digital broadcasting, as well as for the data relevant to existing analogue television stations and other primary services (this to be used between the two sessions and during the second session).
- Agreement on the regulatory and procedural aspects of the whole planning exercise and the adoption of the new plan.
  - Agreement on the definition of the planning area, and on the expected planning.
  - Plans associated with the new agreements (the new plan and the two plans for the remaining parts of the ST61 and GE89 agreements.
  - A proposal for the date of entry into force of the agreement not earlier than 12 months following the second session; this decision will be taken by the second session.
  - No single agreement on the transition period; two options were retained as follows:

During the transition period, the existing and planned analogue assignments will continue to be used and protected by the new digital plan. After this period, analogue assignments may continue to be used, provided that:

- protection is afforded to the new digital plan and its modifications;
- no protection is claimed from the new digital plan and its modifications.

This period starts at the date of entry into force of the new agreement and ends on a date to be agreed by the second session.

Two options have been identified so far with respect to this second date:

– Option 1

  As early as possible and preferably not later than 2015; however, longer or shorter transition periods may be agreed multilaterally provided they do not affect other administrations concerned.

– Option 2

  No earlier than 2028 and not later than 2038; however, shorter transition periods may be agreed multilaterally.

It is up to each administration to decide on the date as of which its analogue transmissions will cease.

All developing countries, without exception, opted for option 2 for the following reasons:

a) No urgent need for terrestrial broadcasting to go digital.

b) Protection of users using analogue TV receivers.

c) The availability of much satellite broadcasting transmitting digital signals but received using existing analogue TV receivers with the help of a converter (digital/analogue converter).

d) Not all of them have used existing available analogue channels in both Stockholm 61 and Geneva 89 analogue plans.

  • An agreement on the necessary procedures to be developed between the two sessions.

  • The adoption of many resolutions, which will facilitate technical studies by study groups, and the planning exercises between the two sessions led by both the Intersessional Planning Group (IPC for planning exercises) and the Regulatory/Procedural Group (RPG) to study the regulatory/procedure issues, with both groups reporting to the second session.

Chapter V

Conclusions

Traditionally, broadcasting and telecommunications have been treated as separate, vertical markets. Digital convergence, which means the same digital content can be transported over any of those networks, has a potential to create new horizontal markets within each level of the value chain such as content, service provision, network operation and terminals thereby opening up an abundance of new business opportunities. For the first time, people would be able to access any multimedia services from all type of delivery platforms such as fixed, portable and mobile with reasonable costs.

Switchover, i.e. the transition, from analogue to digital broadcasting is a complex process with social and economic implications going well beyond the pure technical migration. Digital broadcasting development is positive as it improves both the range and quality of services, notably thanks to digital compression. This increases both spectrum efficiency and network payloads.

Sound and Digital TV switchover should be an inclusive process encompassing various networks, business models and services, including free to-air TV, better picture quality or data and interactive services. Analogue switch-off should only take place when digital broadcasting has achieved almost universal penetration, taking all the above possibilities into account, to minimize social cost. Policy intervention should take place at national level in the first instance, considering market and policy differences between Member States in the area of broadcasting. However, the ITU has also a role to play, in particular in view of the internal market aspects. Possible ITU contributions concern notably: benchmarking, equipment standards, consumer information, facilitating and promoting access to added value services.

The industry is in the process of developing technologies that will make digital convergence a reality. Digital convergence allows content and service providers to deliver their offers through multiple delivery mechanisms. Correspondingly, consumers can access services via various terminals capable of consuming multimedia content and more services via a single terminal. This blurs the borderlines between the traditional broadcasting and electronic communication sectors and consequently has a profound effect in the future of media distribution. Consequently, future regulatory provisions must be carefully drafted to reflect those changes.

5.1 Regulatory considerations

Regulation should allow multimedia service provision through all types of delivery networks, and regulations should ensure that a level playing field exists for all actors in the new horizontal markets and should correct imperfections of the market. To facilitate this process, the existing political and regulatory structures need to be adapted.

It is also important that spectrum policy (which includes and takes into account items such as allocations, assignments, and liberalization) provide access for all contenders in a harmonized, open, transparent and non-discriminatory way, and the means for sufficient and appropriate delivery capacity. In order to facilitate the development of global service and delivery, as well as interoperability and economies of scale in the production of equipment, a globally harmonized spectrum usage should be encouraged, without preventing, at the same time, the flexibility needed for the creation of a competitive and technologically advanced scenario through spectrum management and licensing. In addition, the spectrum usage should also allow for regional differences in the amount of spectrum required for content delivery and for interactive services, since customer demand and interest may differ between regions.

Both telecommunications and broadcast networks have until now evolved under separate, vertically oriented standards and regulations. Broadcasting has been for radio and TV, and telecommunication has been for voice. Recently also data communications has evolved under its own IT-labelled umbrella. With digitization the borderlines between telecommunication, TV and radio services and data communication are disappearing. As a result, it will become increasingly difficult to define or categorize future delivery structures by the type of services that are delivered through them. Accordingly, new definitions will be needed in relation to regulatory aspects.

The new regulatory environment should also allow multimedia service provision through all types of delivery networks (broadcasting and mobile). In fact, network usage expands and becomes more flexible when it is not bound to the transmission of certain kinds of content. The expansion of usage will increase the desire to invest in the building of networks, and their technological improvement.

5.2 Efficient usage of broadcasting spectrum

The migration from analogue to digital broadcasting has already commenced in some countries and is expected to continue throughout the world for the next few years. The actual duration of parallel analogue and digital broadcasting, i.e. the date when the analogue transmissions will end, will vary from country to country (2010 has been stated as an objective for a number of European countries concerning digital TV). However, the remaining countries of Region 1, all developing countries plus Iran, opted for the year 2028 or 2038 to end analogue transmission.

There are a number of elements to this transition:

– The “switch on” of digital TV,

– The “switch off” of analogue TV, and

– How to deal with the refarmed analogue TV spectrum (refarming).

This development will bring about significant new capacity for new services, as digital content can be broadcast in a fraction of the radio bandwidth that would be required for the equivalent transmission in analogue mode. Consequently, a much larger offering of digital TV programming is technically feasible while using less of the available radio spectrum. Furthermore, new types of digital services and content can be offered through this digital broadcast spectrum, both during the introduction of the digital technology is introduced but even more so also once analogue broadcasting has ceased – even while significantly increasing the quantity of broadcast TV (video) programming. Thus there is a significant opportunity for both additional TV and radio broadcasting, as well as for other interactive services in the fixed, portable and mobile environments, for example IP datacasting and interactive services.

The full benefits of the all-digital future will only be realized once analogue switch-off has been completed. The key issue will be to ensure the availability of many different services by many different service providers, as well as to guarantee openness and neutrality, which will pave the road for innovative services, technological innovation and vigorous competition to the benefit of the consumer and the entire economy.

5.3 Requirements of broadcasting services

5.3.1 Network aspects

The advantage of DVB-T terrestrial broadcasting in terms of portability, mobility, integrated receivers and set-top reception fully justify the maximization of terrestrial coverage. In many countries most households receive analogue broadcasting by terrestrial means. For those households who only want digital free-to-air services there will be a strong expectation of receiving these services by terrestrial means. The existing terrestrial analogue network infrastructure can be fully utilized for this.

The concept of single frequency networks (SFNs) is efficient in saving the spectrum required to offer service to a limited geographical area. By having both 2K and 8K modes as well as several guard intervals, the DVB-T system can offer efficient tools for planning SFNs for various purposes including mobile reception. As is widely known in the broadcasting world, by also using gap fillers or repeaters, transmitters can easily enhance reception with full compatibility with respect to future upgrades, and portable and mobile reception possibilities will be better. This means that network extensions and modification for mobile or portable reception can be implemented at reasonable costs.

Users are moving fast towards a mobile lifestyle. 2G, 3G and future technologies have taught us to use mobile cellular technology in our everyday communication. By receiving mobile broadcasting datacast services over DVB-T/H in conjunction with 2G/3G as a return channel, consumers will be able to receive new kinds of content services and have increased interactivity. Joint utilization of DVB-T/H and cellular network technologies will provide consumers with location-independent and personalized services.

5.3.2 Receiver aspects

There will likely be four main types of receiver:

1) Fixed digital TV and set-top boxes for fixed reception using either roof-top antennas or fixed indoor antennas.

2) Portable TV or radio sets.

3) Car-installed terminals and mobile hand-held terminals, possibly integrating with 2G/3G cellular functions.

4) Mobile/portable broadband wireless systems.

Types 3 and 4, i.e. hand-held and portable terminals, will be battery operated and must focus on low power consumption. Therefore extra care has to be taken to make the radio environment such that this would be possible, and also user-friendly and convenient from the terminal and RF viewpoints. In particular, as regards TV one of the major concerns with the current environment is the placement of digital channels all over the UHF spectrum so that high-power analogue channels are adjacent to digital ones. This sets up very high linearity requirements from the terminal’s RF components, and thus consumes excessive power. Having a unified part of the spectrum reserved only for portable/mobile digital data broadcasting and broadband wireless would help to ease the situation considerably.

5.4 Aspects related to the interoperability of systems

(All sub-chapters describe the situation in the European Union. Other administrations are invited to provide further information on its own scenario).

5.4.1 Digital reception

Ensuring that most users are equipped with digital receivers is the main challenge for switchover and a pre-condition for switch-off. Finding a solution for all receivers in the home, not just the main receiver, just adds to the challenge. The two basic options are digital converters or set-top-boxes connected to analogue receivers, and integrated digital receivers. Moreover, additional reception facilities such as cabling, antennas, dishes, etc are often necessary.

There must be a large range of digital reception solutions to suit various user segments. This means choice of functionality, price and commercial formulas. Equipment cost is not a major barrier to the consumer of pay-TV services since some pay-TV operators subsidize it, having already deployed millions of set-top-boxes. However, pay-TV will not achieve the widespread penetration of digital TV only. Now the main challenge concerns the creation of "horizontal" markets for unsubsidized receivers supporting free-to-air digital TV services, where consumers pay the full cost from day on Co-existence of the two business models is important for wide-spread digital TV market penetration.

Availability of cheap receivers is essential to minimize entry barriers for consumers. Most of them must be equipped before the switch-off can take place. Equipment costs should not be much higher than in analogue and services at least comparable, thus offering a cheap entry point to digital TV. This is the way the market seems to go now. Of course consumers should also have options to buy expensive equipment supporting sophisticated services. Service and equipment diversity also contributes to wide-spread digital TV market penetration.

5.4.2 Encouragement to deployment of digital receivers

Free movement of goods within the internal market requires that national authorities do not impose administrative constraints for commercializing digital broadcasting equipment and compulsory technical requirements.

Some ITU Member States envisage public subsidies for digital equipment through schemes aimed at the whole population or just specific groups. The risk with the first scheme is discouraging purchases, including purchases of more sophisticated equipment than the one subsidized. The risk with the second scheme is trading of devices between subsidized and unsubsidized population groups.

Several other forms of incentives have been considered by some Member States, roe instance temporary and digressive reduction of the license fee for homes with digital equipment to encourage fast digital migration, etc. Some Member States allow a reduced rate of VAT on pay-per-view and subscription broadcasting services. The financial implication and parties affected are different, so each option should be carefully analyzed and implemented.

5.4.3 Consumer information on digital equipment and switchover

Consumer information is crucial to drive digital equipment sales in a market-led approach to switchover. Consumers should be empowered to plan their own migration rather than being forced and thus deprived by this process. They should be well informed of the timing and consequences of switchover so as to take their own decisions on services and equipment from a wide range of choices. They must be aware of what various devices can offer, what are the prospects of analogue equipment obsolescence and the possibilities for upgrading. Information and labeling should also be available in accessible formats for consumers with disabilities.

Informing consumers is the responsibility of equipment manufacturers, retailers and service providers, who need to co-ordinate their action and send clear messages whilst respecting competition law. Labeling schemes for analogue and digital equipment, with explanatory notices and/ or logos, based on voluntary industry commitment, would be particularly useful. The goal would be to send consumers positive and negative signals about, respectively, digital-compliant and analogue-only receiver equipment. This information should mirror national switchover policies, including indicative national or regional switch-off dates. Especially as an analogue switch-off date approaches in a particular Member State, its consumers should be clearly warned about the risks of equipment obsolescence.

Policy intervention in this area has been proposed in some EU and third countries. However, Member States cannot impose *de jure* or *de facto* compulsory labeling schemes without prior notification. Notification enables a compatibility assessment of such measures with internal market rules to be undertaken. Where necessary, a certain degree of harmonization could be envisaged so that the approach to labeling would be common whilst tailoring its implementation to local circumstances, such as national switch-off dates. Labeling specifications could be approved by consumer and standardization bodies.

5.4.4 Integrated digital television receivers

The prohibition of selling analogue-only television receivers according to a staggered calendar has been recently approved in the United States and debated in some EU Member States. All countries would have to implement the obligation more or less simultaneously to preserve homogeneity within the internal market. This would have greater impact in countries where digital penetration remains low and strain the principle of subsidiarity traditionally applied in broadcasting policy.

Another potential drawback of compulsory integrated digital receivers would be the extra cost for consumers which, depending on the exact technical requirements, could however be partly offset by economies of scale. The impact would be greater in those countries where digital TV is less developed. Concerns can be also raised as to the technological neutrality of the measure. If only one type of digital tuner were to be mandated, this would presumably favor the dominant analogue TV network, often terrestrial.

5.4.5 Digital connectivity

Currently, digital TV signals are almost always displayed on analogue TV sets connected to a digital set-top-box, which decodes those signals, through the analogue ’SCART’ socket or connector. That means digital signals are converted into analogue signals before being displayed. This is acceptable for today’s television receivers, based on cathode ray tubes and small screen sizes. However, the quality penalty is more perceptible on big screens using new digital display technologies. Moreover, the lack of systematically implemented and enabled digital connectors prevents the transfer of digital information between digital TV receivers and other digital devices in the home. But digital connectivity raises copyright security concerns, in particular that insufficiently protected digital content could be illegally copied or distributed. The possibilities for implementing digital connectors should be further explored as an incentive to consumer equipment switchover. A number of options exist to interconnect digital TV equipment, fulfilling different requirements but it is still unclear which way the market will go.

5.4.6 Interoperability of services

Regarding more sophisticated functionalities such as *Application Program Interfaces* (API), interoperable and open solutions for interactive TV services must be encouraged. The Member States will decide whether it is necessary to mandate certain standards to improve interoperability and freedom of choice for users. Indeed, these two criteria will likely contribute to consumer uptake of digital broadcasting in a market-led switchover scenario, thus minimizing the need for public intervention.

5.4.7 Access for users with special needs

Access to digital broadcasting should include citizens with special needs, notably people with disabilities and older persons. However, while digital broadcasting offers greater possibilities than analogue in this area, these are not yet supported by digital equipment on the market. Harmonized approaches can reduce costs through economies of scale, thus facilitating the marketing of relevant functionalities.

5.4.8 Removal of obstacles to the reception of digital broadcasting

Infrastructure competition stimulates market development, increasing consumer choice, quality of service and price competition. This may be constrained in some areas by legal, administrative or contractual restrictions on the deployment of infrastructure or reception facilities. Authorities will need to arbitrate between promoting digital broadcasting and the fundamental freedom to receive information and services, therefore facilitating network competition, and other policy objectives on town planning, environmental protection or other areas. With that proviso, national authorities should encourage network competition. By way of example, some Member States have already adopted measures in support of this objective, for instance by requiring the provision of multi-network reception facilities in new apartment blocks, facilitating their installation in existing blocks (for instance by reducing the required threshold of tenants' votes), or by removing restrictive clauses in property or renting contracts. Co-ordination between national and local authorities is important since local authorities are often responsible for the practical implementation of this type of measure.

5.5 Effects on citizens

In all transition periods there are a lot of actors, but the past has shown the principal actors are the users. The decision of the users is in all cases oriented by market forces that, driven politically by Administrations and Manufacturers with the support of Broadcasters, can promote the opinion for change to oldest analogical systems and buy the new digital equipment. What is very important and urgent is the coordination among the different actors. In fact if the users are ready to buy new equipment and the manufacturers have produced the equipment, is very important to have a "frequency planning" program prepared by Administrations and, at the same time, a sufficient number of programs emitted, with interesting contents attract the attention of users and promote the change.

The users are moving fast towards a mobile 2G/3G lifestyle and future technologies have taught us to use mobile technology in our everyday communication. By receiving mobile broadcasting services in conjunction with 2G/3G as a return channel, consumers will be able to receive a new kind of content services and have increased interactivity. Joint utilization of digital broadcasting and existing and new cellular/cellular-type network technologies will provide consumers with location-independent and personalized services. Additionally, the delivery of digital media content via several distribution channels strengthens the availability of information society services, as they could be provided in various manners, via different network transmission methods. The use of more extensive and diverse communication networks promotes the availability of additional services and the development of content and receivers at affordable prices. This will mean information society services, including public services, can be made more accessible and cheaper than ever for all citizens by combining the usage of different types of distribution communication networks or by offering them via one communication network.

For digital television and radio the crucial conditions for success require a public that is informed on the facilities and benefits offered by the new digital services, including technical enhancements, additional programmes and services. The public must be aware of the additional service opportunities digital broadcasting and consumer electronics will offer. (For example, initiatives in this direction (i.e. to raise the public's awareness) are already ongoing in some European countries.) In addition, geographical access to digital services should be maximized and the new services should be accessible on the shortest time-scale.

Open access to public services of the information society should be encouraged, and directly developed whenever possible. This will support and speed up the implementation and success of digital broadcasting and additional datacast services. The lifetime of consumer products is in general expected typically to be from 5 to 10 years, and in some instances more. This requires stable systems, open access and the possibility of upgrading. This can only be assured when there are common, widely adopted standards jointly agreed among market players.

NOTE – RCC-04/06

With regard to the conclusions of RCC-04, the key points concerning replanning of the broadcasting spectrum are listed below:

- Regional replanning should facilitate the regionally harmonized, flexible and spectrum-efficient deployment of digital broadcasting.
- Eventually the digital broadcasting TV spectrum bands 174-230 MHz and 470-862 MHz should be made available in a flexible and spectrum-efficient manner allowing opportunities also for, other digital converging services (such as IP datacast, etc.).
- Planning will assume that traditional digital TV will account for the largest use of current analogue spectrum but may also take into the account services other than TV.
- At national level, the frequency assignments and licensing policy and process should facilitate a quick full deployment of potentially nationwide digital broadcasting service networks for fixed, portable/nomadic and mobile applications.
- The results of RCC-06 will have its implications on many of the previous assumptions.

Chapter VI

Case studies[4]

6.1 OECD and broadcasting

In the OECD document emitted in June 2003 with the following title: "The Implications of convergence for regulation of electronic communications" from the Committee for Information, Computer and Communications Policy; the major part is dedicated to the place of broadcasting in electronic communications (Doc. DSTI/ICCP/TISP (2003)5).

After the introduction:

1) Convergence in electronic communications is bringing together industries in the communications area which were previously viewed as separate in both a commercial and technological sense, and which have quite distinct regulatory traditions and arrangements. This is leading many governments in OECD countries to review their policies in the communications sector.

2) Convergence refers to the process by which communication networks and services, which were previously considered separate, are being transformed such that:

- Different network platforms carry a similar range of voice, audiovisual and data transmission services
- Different consumer appliances receive a similar range of services and
- New services are being created.

Part A develops the subject of broadcasting structure, regulation and forces for change.

The broadcasting industry has undergone substantial structural change over the last two decades. Until the early 1980s, the industry was relatively homogeneous. Broadcasters transmitted their services over the air waves (terrestrial transmission) and scarcity of spectrum and analogue technology restricted the number of channels. The industry was often defined by its "point to multi-point" format; a broadcaster transmitted its programmes, which could be received at the same time by all citizens who had a radio or television set. Services were available "free to air"; viewers and listeners did not have to pay to receive particular channels or programmes. However, licence fees were collected in many countries to fund, or partially fund, public service broadcasters.

In most European countries, licences were restricted to public service broadcasters; In the United States, commercial broadcasting financed by advertising was the norm. Other countries, such as Australia and New Zealand, combined the two approaches. In all cases, broadcasters did not have a direct economic relationship with their viewers or listeners. In the European model, the governing boards of the public broadcasters interpreted the "needs" of viewers and determined the programming which broadcasters should offer. Under the commercial model, broadcasters determined programming on the basis of its ability to attract advertising revenue at minimum cost. Under both approaches the preferences of viewers did not have a direct impact on the type of programming the industry provided.

In most OECD countries there is a mix of public and private terrestrial broadcasters, transmitting from one to eleven channels with a national coverage. Seventeen countries have from three to six national channels. Luxembourg and Mexico do not have a public broadcasting network, while Austria, Denmark, the Republic

4 The majority of these case studies are belonging to developed countries.

of Korea, the Netherlands and Switzerland do not have commercial, terrestrial broadcasting with national coverage. However, Denmark, the Republic of Korea and Switzerland license commercial broadcasters to transmit locally.

A number of different models are used to finance and operate the terrestrial transmission network. In many European countries, the network is owned and operated by the public sector broadcaster or the incumbent telecommunication operator or a special public sector agency. In North America and Japan (and Belgium, Greece and Italy) each broadcaster owns its transmission network. Private broadcasters in Australia also follow this approach. In Australia and the United Kingdom, publicly owned terrestrial networks have been sold in recent years and the Irish Government has announced a similar policy.

Satellite and cable have substantially increased the choice, number of channels and range of services available to viewers. In addition to subscription packages, public service broadcasters in a majority of member countries provide additional channels that can only be accessed via satellite or cable. Private domestic channels, funded by advertising, are also only available on satellite and cable where the spectrum constraints are less pressing. Further, satellite allows channels which are intended to be viewed in one country to be compiled and uplifted in another country. For example, TV3 in Denmark is produced in, and transmitted from, the United Kingdom.

The following features are characteristic of broadcasting regulation in the OECD region.

- The level and type of regulation varies according to the delivery platform. Free to air or terrestrial broadcasters are more tightly regulated, reflecting their more pervasive influence in shaping community views.
- Licences are often required for both spectrum use and the provision of a broadcasting service.
- Licences are used to control entry and a wide range of technical and content conditions are attached to licences.
- Public service broadcasters are funded as a contribution to plurality, programme diversity and national identity.
- While most countries have policies directed at achieving cultural objectives, including supporting domestic programming, some countries have a wider range of content obligations. These relate to diversity and quality of programming, the protection of children, upholding community standards in taste and decency and restrictions on advertising to meet national health and consumer protection objectives.
- The wide range of objectives and fragmented policies can result in regulations which are not always consistent (for example, restrictions on the number of broadcasters reduces plurality).

Part B develops the theme of the regulatory reform, discussing the type of regulatory reform which may be necessary to meet the challenges created by convergence and hence ensure that the opportunities are realized.

The proposal involves:

- A regulatory framework structured along activity lines as opposed to the existing vertical framework structured around industries.
  – This is sometimes referred to as a horizontal structure in which carriage and content have separate regulatory arrangements. However, it would be unwise to consider the two regimes as being completely independent. Decisions on some carriage matters can have an effect on cultural and social objectives and vice versa.

- A common regulatory regime for the carriage of all electronic communication services.
- Separate entry procedures for the carriage of a communication service and provision of a broadcasting (content) service.
  - The basis for entry procedures could be different.
  - Entry procedures (in this case licensing), conditions associated with content and restrictions on the ownership of broadcasters should only apply to the licence for the provision of a broadcasting service.
- Incentives for the more efficient use of spectrum, such as:
  - Licence fees for the terrestrial transmission of broadcasting based on the value of spectrum used.
  - Broadcasters able to hand back unwanted spectrum or the development of a secondary market in spectrum could be encouraged.
  - Any restrictions on the use of spectrum should be in the form of minimum levels of broadcasting services which must be provided.
  - The provision of a basic broadcasting service to uneconomic areas should be managed as a universal service obligation (USO) and provided in the most efficient manner possible.
- The use of competition principles and sector-specific regulations to prevent anti-competitive behaviour and ensure appropriate access to infrastructure networks, conditional access systems and content.
  - Move to broader definitions of markets and to the use of "dominance" as the threshold which triggers tighter regulatory scrutiny.
  - Close anti-trust scrutiny of vertically integrated enterprises which control both delivery networks and premium content.
  - An *ex ante* presumption that gatekeepers cannot unreasonably deny or delay access to delivery networks, operating systems such as application programme interfaces (APIs) and premium content.
- Plurality of voice objective achieved by using the additional capacity provided by digital to increase the number of broadcasters and by reliance on competition policy and a public interest test.
  - Legislation to recognize explicitly the potential for tension in using competition policy to achieve both economic and social objectives and give clear guidance on the importance of the plurality of voice objective.
  - Approval of mergers in the media sector to require approval under both the usual economic assessment and the public interest test.
  - Similarly, decisions on whether to apply access regimes would take account of both criteria.
- Replacement of domestic content transmission quotas with equivalent subsidies for the production of domestic programmes and audiovisual services as a means of achieving the objective of cultural diversity.
- Continued financial support for public broadcasting as a means of contributing to the objectives of plurality and diversity.
- Institutional arrangements structured so that a single regulatory body deals with conditions of access and use of electronic communication networks.

6.2 Digital video broadcasting spectrum issue in Europe

This chapter gives the general opinions of European manufacturers and deals with allocations and use of spectrum for broadcasting applications and directly related regulatory and technical aspects in Europe, focusing on broadcasting spectrum bands 48-68, 174-230 and 470-862 MHz.

Digital convergence allows content and service providers to deliver their services through multiple delivery channels. Correspondingly, consumers can access services via various terminals capable of consuming multimedia content. This blurs the borderlines between the conventional broadcasting industry and the communications industry and consequently has an effect on the future of media distribution. A concrete example of this development is datacasting, i.e. the delivery of multimedia content and services via digital broadcasting networks. Industry has developed technologies that will make digital convergence a reality.

Traditionally, broadcasting, telecommunications and the internet have been treated as separate vertical markets. Digital convergence has a potential to create new horizontal markets within each level of the value chain such as content, service provision, network operation and terminals, opening up an abundance of new business opportunities. For the first time, people would be able to access any multimedia services from all types of delivery platform such as fixed, portable and mobile.

a) Regulatory context

Regulation should allow multimedia service provision through all types of delivery network and create a level playing field for all actors in the new horizontal markets. To facilitate this process, the existing political and regulatory structures need to be adapted. It is also important that spectrum allocation decisions provide sufficient and appropriate delivery capacity. In order to facilitate the development of global service and delivery, as well as interoperability, a globally harmonized spectrum usage should be encouraged through spectrum management and licensing.

The introduction of the EU Electronic Communication regulatory package (2002) provides the opportunity to remove impediments. Concerning the manufacturers, the implementation of such regulation shall aim at achieving the following goals:

– Review those regulations that prohibit the delivery of multimedia content over any delivery channel.

– Provide a level playing field for all parties operating in horizontal markets.

– Make sufficient spectrum available for adequate content delivery while encouraging globally harmonized spectrum usage.

The delivery of digital media content via several distribution channels strengthens the availability of information society services via different network transmission methods. The use of more extensive and diverse communication networks promotes the availability of additional services and the development of content and receivers at affordable prices. Public services can be made more accessible than ever for all citizens by using different communication networks. Digital data TV will play a crucial role in making available to viewers portable and mobile reception with interactivity and local services.

Network usage expands and becomes more flexible when it is not bound to the transmission of certain kinds of content. The expansion of use increases the desire to invest in the building of networks.

Also, in the long run, the digitization of television networks will have an effect that reduces transmission costs. In place of the current single stream of programming, at least four to six streams of programming could be broadcast by the same transmitter and on the same channel. A portion of the capacity of the radio and television broadcasting channels could also be used in a flexible way to provide additional services. In this case, radio frequencies could be used more efficiently and the use of limited natural resources can be optimized.

b) Broadcast efficiency spectrum

In some countries in Europe the available spectrum is large enough to accommodate both the traditional digital broadcasting services and new services like the transfer of data files such as product catalogues, software applications, games and news. The full benefits of an all-digital future will only be obtained once analogue switch-off has been completed. Services in a given multiplex should be allocated in line with overall network capabilities. It could make sense to give a portion of the capacity of a multiplex to other than traditional TV services. The key issue is to ensure the availability of many different services by many different service providers, in order to ensure innovative services and vigorous competition to the benefit of the consumer and the entire economy.

c) Infrastructure implementation

Both telecommunications and broadcasting networks have hitherto evolved under separate, vertically oriented standards and regulation. Broadcast has been for radio and TV and telecommunications for voice. Recently also datacommunication has evolved under its own IT-labelled umbrella. With digitization the borderlines between telecommunication, TV and radio services and data communication are disappearing. As a result, it will become increasingly difficult to define or categorize future delivery structures by the type of services that are delivered through them. Accordingly, new definitions will be needed in relation to regulatory aspects.

It is necessary to establish a harmonized European deadline for switching off analogue TV transmission. In relation to digital television and other digital services offered to the public over broadcasting technologies, a clear statement of public policy for switchover is essential.

For television and radio the crucial conditions for success require a public that is informed on the facilities and benefits offered by digital services, including technical enhancements, additional programmes and services. The public must be aware of the additional service opportunities digital broadcasting and consumer electronics will offer. In addition, geographical access to digital services should be maximized and the new services should be accessible on the shortest time-scale.

Open access to all public information society services should be developed and standardized. This will support and speed up the implementation of digital TV and additional datacast services. The lifetime of consumer products is generally expected to be from 5 to 10 years and over. This requires stable systems, open access and the possibility of up-grading. This can only be ensured when there are common, widely adopted standards and the system is jointly agreed among market players.

6.3 Communication from European Commission on the transition from analogue to digital broadcasting

The European Commission edited the 17 September 2003 a 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) 992

The executive summary report is the following:

"Switchover", i.e. the transition, from analogue to digital broadcasting is a complex process with social and economic implications going well beyond the pure technical migration. Digital broadcasting development is positive as it improves both the range and quality of services, notably thanks to digital compression. This increases both spectrum efficiency and network payloads.

This Communication addresses the switchover process, with a special focus on Member States' policies for digital TV migration. The Action Plan *eEurope 2005* requests Member States to publish their intentions regarding switchover by December 2003 (See 6.4). This Communication suggests the type of information that could be included in such reports.

Market forces and consumer demand must drive broadcasting digitization, which is a major industrial challenge. Business freedom and incentives are instrumental to this goal. It is also crucial to inform consumers so that they know when to migrate and what the options are. This should be a market-led process, not a simple infrastructure change with no added value for citizens. Successful switchover will be facilitated by co-ordinated action from the numerous players involved – broadcasters, equipment manufacturers, retailers, governments and others.

Member State policy interventions should be transparent, justified, proportionate, and timely to minimize the risks of market distortion. They should be formulated according to clearly defined and specific policy goals and market difficulties. This requires careful impact assessment as well as monitoring of policy implementation and market evolution. Trying to force switchover against industry and users' interest may lead to unsustainable outcomes.

Member State policy interventions should also be non-discriminatory and technologically neutral. Differentiated treatment of market players must be justified. Digital TV switchover should be an inclusive process encompassing various networks, business models and services, including free-to-air TV, better picture quality or data and interactive services. Analogue switch-off should only take place when digital broadcasting has achieved almost universal penetration, taking all the above possibilities into account, to minimize social cost.

Policy intervention should take place at national level in the first instance, considering market and policy differences between Member States in the area of broadcasting. However, the EU has also a role to play, in particular in view of the internal market aspects. Possible EU contributions concern notably: benchmarking, equipment standards, consumer information, facilitating and promoting access to added value services. The Communication also proposes to launch a debate on spectrum aspects of switchover within the new Community spectrum policy framework. This would address possible approaches for greater transparency about the economic value of spectrum allocated to terrestrial broadcasting services. The top-level objective is to encourage efficient and flexible spectrum usage, while preserving the service mission of broadcasting.

It is not envisaged to propose a common switch-off date or the prohibition of selling analogue receivers at EU level. However, national digital broadcasting markets and policies will continue to be monitored.

At the end of this Communication, the conclusions are:

Switchover from analogue to digital broadcasting is a complex process with far-reaching implications. Experiences will widely differ from one national context to the other, given the different starting positions of Member States. The EU will monitor national switchover policies, while ensuring their compatibility with Community law, and continue supporting digital broadcasting developments.

Policy intervention can facilitate the switchover process under certain circumstances, contributing to achieve general interest goals. National authorities have a major role to play in this connection, and the present Communication offers some guidance to them. This consists of general recommendations inspired by Community law and policy, and by external studies undertaken for the Commission. Recommendations include the need for a market and consumer-driven approach, policy transparency and non-discrimination between operators. Proportionality and technological neutrality should characterize public policy measures at national level.

There is also an internal market dimension to switchover and the Union can facilitate this dimension. Several follow-up actions are identified at EU level, in particular concerning:

Transparency and monitoring: Member States will provide information relevant to switchover in the framework of the Action Plan *eEurope* and the annual report on the implementation of the electronic communications regulatory package. The Commission will analyse this information and report back to the institutions to which this Communication is addressed.

Consumer information on digital equipment and switchover: the Commission will explore with relevant stakeholders the possibility of co-ordinated action in this area.

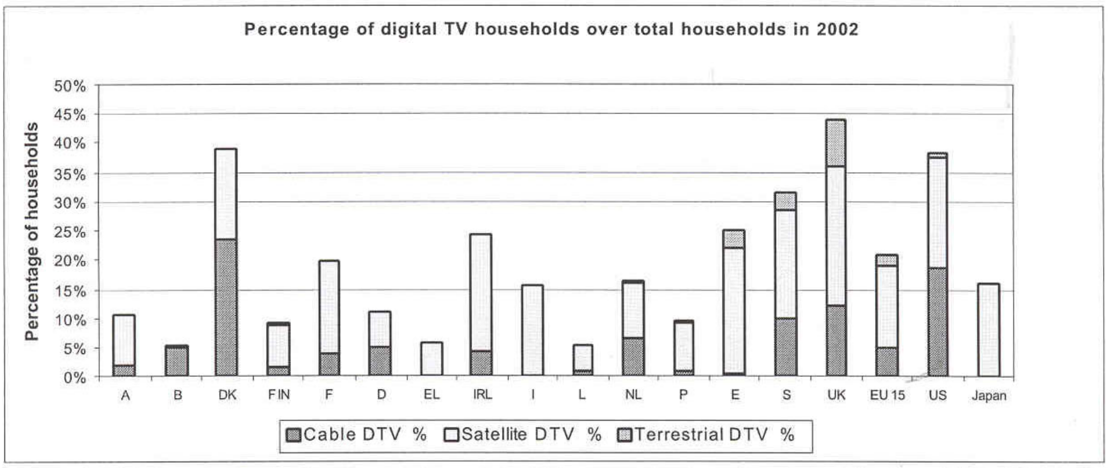
Spectrum: the Commission will propose to Member States to discuss the spectrum aspects of switchover within the new Community spectrum policy framework.

This Communication is the first comprehensive attempt to assess the issues invoked by switchover. The Commission will continue to monitor the evolution of digital broadcasting markets and national policies. It will revisit as appropriate various issues relevant to the switchover process, in order to facilitate the efforts of Member States and market players, and to ensure compatibility of national measures with Community law and policy.

DIGITAL TV MARKET IN THE EU (estimates for 2002)

(in millions and in percentage of national households)

	Total HH	Total Digital TV HH		Cable DTV		Satellite DTV		Terrestrial DTV	
		TV HH	%	TV HH	%	TV HH	%	TV HH	%
Austria	3.3	0.36	10.7%	0.07	2.1%	0.29	8.7%	0.00	0.0%
Belgium	4.3	0.23	5.2%	0.22	5.0%	0.01	0.2%	0.00	0.0%
Denmark	2.4	0.92	38.9%	0.55	23.6%	0.36	15.3%	0.00	0.0%
Finland	2.3	0.22	9.4%	0.04	1.6%	0.17	7.3%	0.01	0.5%
France	25.1	4.97	19.8%	0.95	3.8%	4.02	16.0%	0.01	0.0%
Germany	37.9	4.14	10.9%	1.94	5.1%	2.21	5.8%	0.00	0.0%
Greece	3.6	0.22	6.0%	0.00	0.0%	0.22	6.0%	0.00	0.0%
Ireland	1.3	0.32	24.4%	0.06	4.4%	0.26	20.0%	0.00	0.0%
Italy	20.1	3.13	15.6%	0.02	0.1%	3.11	15.4%	0.00	0.0%
Luxembourg	0.2	0.01	5.3%	0.00	1.0%	0.01	4.2%	0.00	0.0%
Netherlands	7.1	1.16	16.5%	0.45	6.4%	0.69	9.8%	0.02	0.3%
Portugal	3.6	0.34	9.6%	0.04	1.1%	0.29	8.0%	0.02	0.5%
Spain	12.8	3.21	25.1%	0.05	0.4%	2.78	21.8%	0.38	3.0%
Sweden	4.6	1.44	31.6%	0.46	10.0%	0.84	18.4%	0.15	3.2%
UK	26.3	11.51	43.8%	3.23	12.3%	6.22	23.7%	2.06	7.8%
TOTAL EU	**154.73**	**32.2**	**20.8%**	**8.1**	**5.2%**	**21.5**	**13.9%**	**2.6**	**1.7%**
US	118	44.95	38.1%	21.8	18.5%	22.55	19.1%	0.6	0.5%
Japan	41.9	6.7	16.0%	0	0.0%	6.7	16.0%	0	0.0%



Source: *Eighth Report on the Implementation of the Telecommunications Regulatory Package* [COM(2002) 695 final], annex 2 ('regulatory data'), section 11 ('digital television') available at http://europa.eu.int/information_society/topics/telecoms/implementation/annual_report/8threport/index_en.htm and *Strategy Analytics, "Interactive Digital TV market forecast data"*, October 2002.

6.4 eEurope Action Plan 2005

The eEurope initiative was first proposed by DG INFSO (Direction Generale Information Society) at the end of 1999 and endorsed by the European Council in Feira in June 2000. The main objective of eEurope is an ambitious one: to bring every citizen, school and business online and to exploit the potential of the new economy for growth, employment and inclusion. The first eEurope Action Plan, 2000-2002, had three aims: a cheaper, faster, more secure internet, investment in people and skills, and greater use of the internet. It consisted of 64 objectives and nearly all were successfully reached by the end of 2002.

The second stage is the **eEurope 2005 Action Plan**, which was endorsed by the European Council in Seville in 2002. The eEurope 2005 objective is that Europe should have modern online public services (e.g. eGovernment, eLearning, eHealth) and a dynamic eBusiness environment. As an enabler for these, there needs to be widespread availability of broadband access at competitive prices and a secure information infrastructure.

eEurope 2005 objectives

The objective of the new action plan is to provide a favourable environment for private investment and for the creation of new jobs, to boost productivity, to modernize public services, and to give everyone the opportunity to play a role in a global information society; eEurope 2005 aims to stimulate secure services, applications and content based on a widely available broadband infrastructure.

The challenges of eEurope 2005

The Information Society has a vast untapped potential for improving productivity and quality of life. This potential is growing due to the technological developments of broadband and multi-platform access, i.e. the possibility of connecting to the internet via means other than the PC, such as digital TV and 3G mobile phones. These developments are creating significant economic and social opportunities. New services, applications and content will create new markets and provide the means to increase productivity and, as a direct result, growth and employment throughout the economy. They will also provide citizens with more convenient access to information and communication tools.

The targets of eEurope 2005

eEurope 2005 applies a number of measures to address both sides of the equation simultaneously. On the demand side, actions on eGovernment, eHealth, eLearning and eBusiness are designed to foster the development of new services. In addition to providing better and cheaper services to citizens, public authorities can use their purchasing power to aggregate demand and provide a crucial pull for new networks. On the supply side, actions on broadband and security should advance the roll-out of infrastructure.

Measures taken under the eEurope 2005 Action Plan

The eEurope 2005 Action Plan is based on two groups of measures, which reinforce each other. On one hand, it aims to stimulate services, applications and content, covering both online public services and e-business. On the other hand it addresses underlying broadband infrastructure and security matters. (see www.europa.eu.int/information_society/eeurope/index_en.htm)

6.5 DVB-T Implementation in Europe

Experience in the introduction of digital terrestrial television (DTT) within Europe is currently to be found in six countries having opened up to DTT with differing results. Those countries are, in chronological order:

- **United Kingdom**

It was the United Kingdom that first pioneered DTT in November 1998 through the operator ONdigital, renamed ITV in 1999, which secured 1.3 million subscribers in three years thanks to a marketing policy that included a free decoder. However, as a result both of competition from the digital satellite packages proposed by certain operators and of its own debts, ITV's subscription rate fell by 23% and it had to cease operations. In July 2002, it was taken over by a consortium, comprising a satellite television operator, the State radio and television operator BBC, and a component manufacturer. It is currently the sole provider of DTT in the United Kingdom, with 30 television channels and 20 radio frequencies. This package is available to three out of every four British households, and has been taken up by 12.2% of households.

As part of the strong competition in the television market, a satellite television group has announced its intention to launch a free digital package in late 2004, with access to 116 television channels and 81 radio stations. While this package will be freely accessible (with no monthly charge), its users will have to invest in the necessary reception equipment. The market for this type of service is expected to comprise those viewers not currently served by DTT (in the order of 27%).

- **Sweden**

In 1999, Sweden launched DTT with three multiplexes, the launch offer having essentially been free of charge. However, the service ran up against competition from cable television, whose penetration rate exceeds 60%. After four years of operations, only 2% of Swedish households (in the order of 200 000) have acquired a decoder. Following an examination of the financial situation of the State channel, the Swedish Government decided to release subsidies to reduce the sales price of decoders.

- **Spain**

Spain was the third European country to provide a DTT service. A commercial package was launched in May 2000, but the operator went into liquidation in April 2002. The available frequencies will be redistributed by the Government. Fewer than 20 000 television sets out of 26 million are capable of receiving digital transmissions.

- **Finland**

DTT was launched in August 2001, with approximately 321 000 households out of 2.4 million having acquired a digital decoder.

- **Germany**

DTT was officially launched on 1 November 2002. At the end of 2003, some six million people are able to receive 26 digital channels in the province (land) of Berlin-Brandenburg. This success can be ascribed in part to the Government, which decreed that the service was to be totally free of charge, and which provided free decoders to the poorest households.

See Section 6.8.

- **Italy**

DTT was officially launched in 2003 under a private operator, which by May 2003 had some 300 000 subscribers and covered 50 to 60% of the national territory. The Italian Government foresees the end of the changeover from analogue to digital broadcasting in 2006.

Note regarding France

In June 2004, the *Conseil supérieur de l'Audiovisuel* (CSA), France's regulator for radio and television broadcasting frequencies, decided to launch DTT, as follows:

- 1 March 2005 for free-of-charge channels:
  - seven existing analogue channels to be migrated to digital
  - four new channels
  - three existing cable channels

In other words, a total of 14 channels.

- 1 September 2005 for pay channels, i.e. 15 channels that are already available via cable, satellite or ADSL.

As from early 2005, the free-of-charge channels will cover some 35% of the French population, with the CSA expecting 50% of the population to be covered by September 2005, when the DTT pay channels are due to become operational.

6.6 Case study: Brazil

The digital terrestrial television broadcasting channel planning

6.6.1 Introduction

This chapter presents the work that was conducted by the National Telecommunications Agency *(Agência Nacional de Telecomunicações – Anatel)* associated with the channel planning for the introduction of the Digital Terrestrial Television Broadcasting (DTTB) in Brazil. The text consolidates five contributions (2/093, 2/095 and 2/185, 2/233 and 2/293) the Brazilian Administration presented to the Rapporteur's Group on Question 11-1/2 during the meetings held on 8 September 2003, and 31 May 2004, 12 September 2004 and 13 September 2005, all 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 chapter presents the methodology, the results and the work Anatel undertook on the completion of the DTTB channel planning. It is important to note beforehand that the country's channel planning is not DTTB standard-specific, since it holds the particularities of each existing DTTB standards.

6.6.2 Methodology Applied for Digital Terrestrial Television Channel Planning and its Respective Results

This section concerns the methodology applied by Brazil to prepare its channel planning for the deployment of the DTTB in the country and its results. The application of this methodology is independent upon the DTTB standard that will come to be adopted. A working group under the coordination of Anatel has developed the digital terrestrial television channel planning since 1999. The Center for Telecommunications Research and Development Foundation (*Fundação Centro de Pesquisa e Desenvolvimento em Telecomunicações* – CPqD) and representatives from the Brazilian TV networks support technically this working group.

6.6.2.1 Premises for digital television channel planning

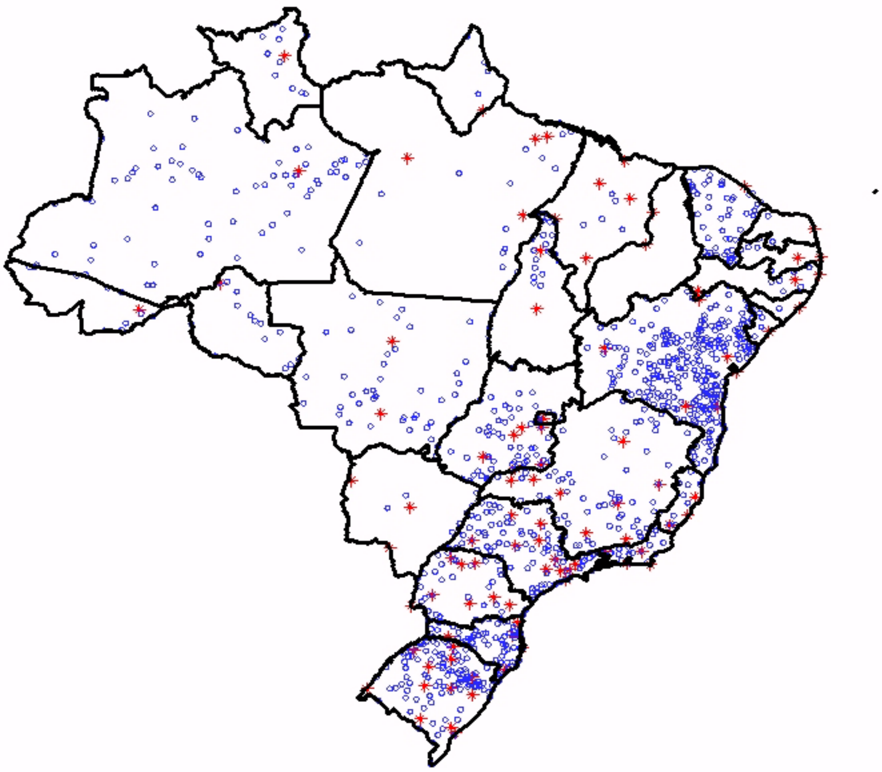
It is noticeable, however, that Brazilian TV networks present quite different characteristics from one to another. They can be either regional networks, or national networks, or national networks, which encompass regional networks, or eventually independent full power station with strict local penetration. Figure 1 indicates the distribution of full power 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 and duly taken into consideration. They are as follows:

- digital television is to replace existing analogue TV by using VHF (7 to 13) and UHF (14 to 59) frequency bands;
- the main objective of planning is to assure that the digital television stations will have similar service areas as presently analogue stations do;
- during the initial stage called the "transition phase", analogue and digital channels are to perform simultaneous broadcast (simulcasting);
- digital television planning is to be carried out in two steps: "Phase 1" only for those cities where active full power stations are in place and, in a later stage, "Phase 2" for those cities where only relay stations are in operation and for also shadow areas.

Because of the preparation of the Basic Plan for Digital Television Channel Distribution (PBTVD), which will continue to use the frequency band currently allocated to analogue transmission, Anatel has suspended, since October 1999, the allocation of new analogue channels and further changes of the technical characteristics in the existing channels of regions of Brazil under heavy spectrum congestion. Since February 2002, the same policy was applied to the remaining regions.

Figure 1 (Case study Brazil) – Network with distributed generation and national penetration



6.6.2.2 Phases of digital television channel planning

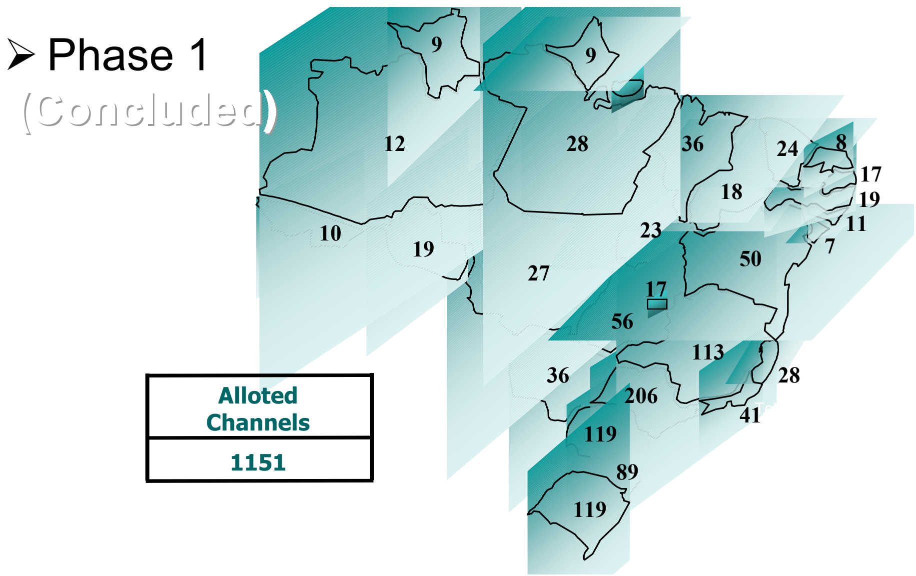
These planning studies were divided into two phases. The first phase represented the availability of the same number of digital channels compared to the analogue channels in service for television and relay stations in operation in all municipalities with, at least, one operating television network service.

The second phase corresponds to the availability of the same number of digital channels compared to analogue channels in service in municipalities whose population is over one hundred thousand inhabitants with only television relay stations. This phase also includes a review of the first phase, in order to meet the demand in all municipalities to which authorizations were granted to install new television operating networks after the beginning of the first phase.

6.6.2.3 Channel planning results

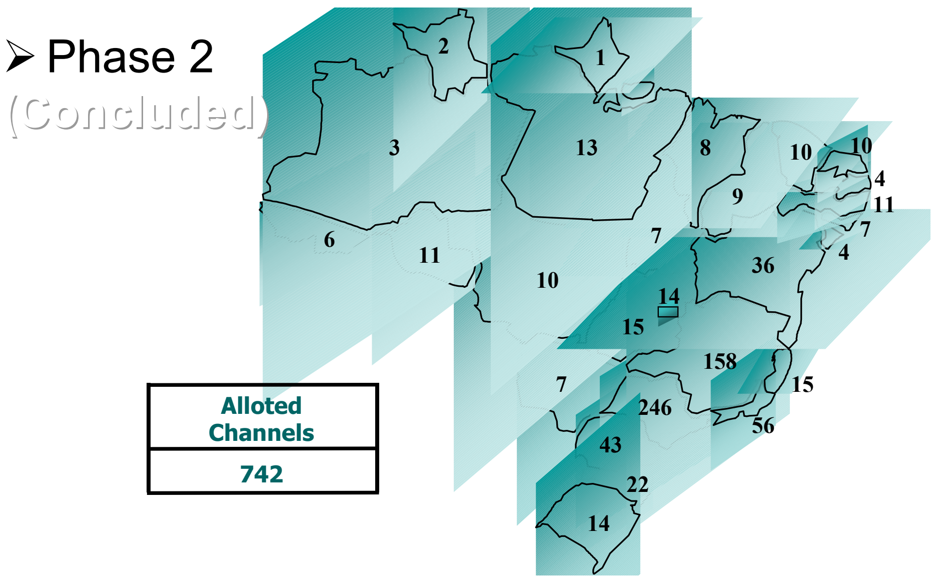
The first phase, concluded in September 2002, made available 1151 digital channels in 164 municipalities, as presented in Figure 2.

Figure 2 (Case study Brazil) – Available digital channels – Phase 1



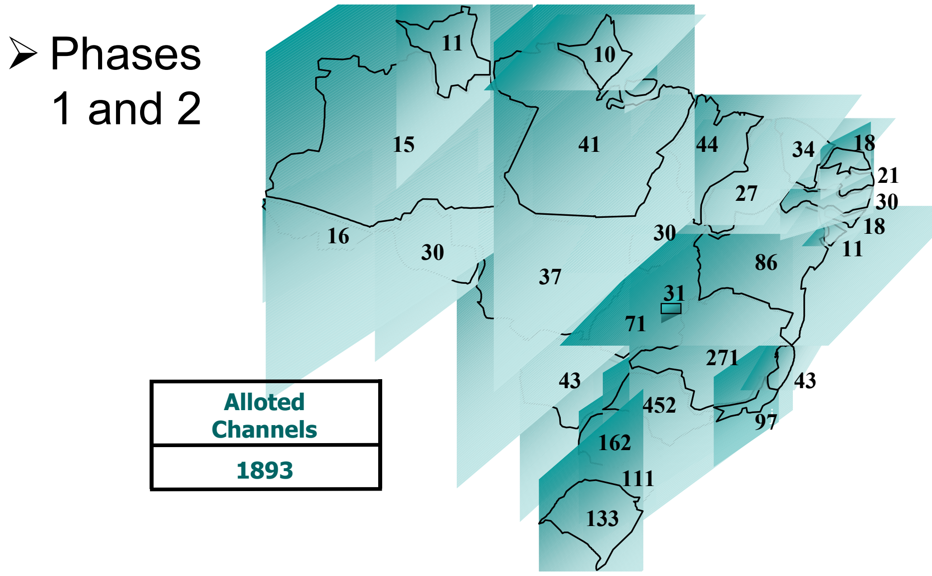
The second phase, concluded in March 2003, made further allocation of 742 digital channels in 132 municipalities, as presented in Figure 3.

Figure 3 (Case study Brazil) – Available digital channels – Phase 2



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.

Figure 4 (Case study Brazil) – Results obtained to date. Digital Channels – Phase 1 and 2



6.6.2.4 The Current Work on the PBTVD

The PBTVD aims, in short, at assuring that the digital television stations have similar service areas as presently analogue stations do. The PBTVD encompasses 296 Brazilian municipalities, whose population is altogether approximately 110 million inhabitants, where either at least one television station service is under operation or municipality's population is over one hundred thousand inhabitants with, at least, one operating relay station. Only the available analogue channels in service were taken into account for the channel planning. As a result, 1893 channels were made available for the introduction of DTTB.

Nevertheless, having recognized the high complexity involved in the establishment of a channel planning, Anatel issued Public Consultation 486/2003 on December 19th 2003,[5] in order to broaden the debate on its DTTB channel planning. The Agency determined March 8th 2004 as the deadline for the submission of comments on Public Consultation 486/2003. Anatel received thirty-eight comments and made them available to the public on the Agency's website.[6] Currently, Anatel is engaged in the analysis of every single contribution received in due term. The Agency will soon proceed with the publication of its analysis of the comments received.

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[5] The Public Consultation is available at: www.sistemas.anatel.gov.br/SACP/Contribuicoes/TextoConsulta.asp?CodProcesso=C487&Tipo=1&Opcao=realizadas

[6] The comments are available at: www.sistemas.anatel.gov.br/SACP/Relatorios/Relatorio1.rpt?rf=1&user0=AcessoLivre&password0=&promptex-@pCodProcesso=C487&promptex-@pCodTipoProcesso=1&promptex-@pTipoRelatorio=1&prompt0=C487

At the same time the Public Consultation was announced, Anatel made also available on its website a technical report prepared by the CPqD.[7] This report established the premises, technical aspects and other important matters that were considered in the process of setting the PBTVD.

Moreover, in order to regulate the methods applied to and to define parameters for calculating the technical feasibility of analogue and digital channels of the PBTVD, the Agency issued Public Consultation 502/2003 on February 16th 2004, which has taken into account the technical report prepared by CPqD. This Public Consultation aims at including a new chapter on Anatel's technical regulation of television broadcasting services, entitled "*Regulamento Técnico para Prestação do Serviços Radiodifusão de Sons e Imagens e do Serviço de Retransmissão de Televisão*", currently in force. The deadline for submission of comments was April 12th, 2004. The Agency is presently analysing the four contributions received.

6.6.3 Conclusion

This Chapter has presented the main events related to the planning of digital television channels to be implemented in Brazil. An essential aspect that will make possible the successful deployment of the digital terrestrial television in Brazil is the assurance that TV stations that nowadays broadcast analogue television programming are made available an extra channel to broadcast simultaneously this very same television programming then in digital format. Therefore, the maintenance of the current free and open TV model remains a sharp requirement in order for the DTTB to play a beneficial role as that the analogue TV today does for the Brazilian society as a whole. Finally, in the light of the comments received in Public Consultations 486/2003 and 502/2003, Anatel expects to consolidate the channel planning for the implementation of DTTB in Brazil in the near future.

6.7 CASE study: Canada an experimental ATSC-DTV distributed transmission network

6.7.1 Abstract

This document presents the design and the field test results of an experimental ATSC-DTV distributed transmission (DTx) network consisting of three coherent translators. The three translators, forming the DTx network, translate the frequency of an over-the-air signal received from a single DTV transmitter to a second RF channel, and cover a common target area in a downtown core, which is also under the coverage of the single transmitter. Such an overlapped coverage area in a hostile downtown environment provides the possibility of testing such a network under worst case conditions. In addition to describing the methodology that is used to design this network, its reception quality in the overlapped coverage area will also be evaluated and compared with that of the traditional single distant transmitter.

In the target area of this network, all field-tests have been performed using two types of ATSC-DTV receivers, a new prototype and a former generation receiver, and two types of receiving antenna, a directional and an omni-directional antenna. This in turn makes it possible to evaluate the performance of the new prototype receiver under severe conditions and to compare it with that of an older generation receiver, and also to investigate the impact of the directivity of the receiving antenna on the reception availability.

6.7.2 Introduction

Distributed transmission (DTx), which is to cover a large service area with a number of synchronized transmitters located at different locations and all operating on the same TV channel, is one of the interesting possibilities that can be provided by digital TV transmission systems.

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7 www.anatel.gov.br/Tools/frame.asp?link=/acontece_anatel/consulta/2003/consulta_486/relatorio_pbtvd.pdf

As explained in the ATSC Recommended Practice for Design of Synchronized Multiple Transmitter Networks [1], DTx networks have a number of benefits over the single central transmitter approach, which has so far been the usual way of covering a large service area with analogue TV transmission. These benefits include:

- More uniform and higher average signal levels throughout the coverage area.
- More reliable indoor reception.
- Stronger signals at the edges of the service area without increasing interference to neighboring stations.
- Less overall effective radiated power (ERP) and/or antenna height resulting in less interference.

DTx networks can also reduce the number of channels used to cover a large service area and can free spectrum for other applications such as interactive TV, multimedia broadcasting, or any other application that may come up in the future.

As a trade-off for these benefits, however, implementation of a DTx network requires a very careful design when a DTV adjacent channel is operating in the same market area [1]. A more serious limitation on the DTx operation is that in the presence of NTSC adjacent channels operating within the same market area, its implementation would be very challenging or even hardly possible. This is because of quite higher protection ratios demanded by NTSC, as compared to DTV, from an adjacent channel DTV. However, such a serious limitation will be ceased after the transition period from NTSC to DTV.

Another important issue affecting the design of a DTx network is the ATSC-DTV receivers' performance with respect to their multipath handling capabilities. Better receivers, capable of handling stronger pre and post multipath distortions (pre and post echoes) on a wider range of delays, make DTx network design more flexible and simpler. On the other hand, receivers with weaker multipath handling capabilities put more restrictions on the design and implementation of DTx networks.

In addition to providing many guidelines for designing a DTx network and managing its internal and external interference under different conditions, the above mentioned Recommended Practice proposes three methods (or their combinations) for implementing a DTx network.

The first method is distributed transmitter network, commonly known as single frequency network (SFN), consisting of a central studio that sends baseband signal or video-audio data stream to the SFN transmitters via studio-transmitter-links (STL). STLs can be fiber optics, microwave links, satellite links, etc., which may be costly to implement and operate. On the other hand, the SFN transmitters in this configuration require subtle (and rather complex) processes for their frequency and time synchronization with each other.

The second method is called distributed translator network in which the transmitters contributing to the SFN, which are some coherent translators all operating on the same channel, translate the frequency of an over-the-air signal received from a main DTV transmitter to a second RF channel. This eliminates the need for a costly Studio to Transmitter Links (STL). On the other hand, frequency and time synchronization for this configuration is quite simpler than the first method. During the translation process to the designated output channel, necessary corrections may also be applied to the signal. In this configuration, however, the main transmitter feeding the coherent translators is operating on another channel and is not part of the SFN. But one may consider this as a sort of frequency diversity in the overlapping coverage area of the main transmitter and the SFN.

The third method consists of digital on-channel repeaters (DOCR) that can differ from each other in the way that they process the signal through the path from their input to their output antennas. The DOCRs contributing to the SFN again pick up their inputs from a main transmitter, eliminating the need for any STL, and transmit on the same channel as they receive. Each DOCR can work on the basis of direct RF operation, conversion to IF or to baseband and up-convert again to the same channel as it receives. In order to form an SFN, however, all the repeaters' outputs should be synchronized with each other and also with the main transmitter feeding them.

With this approach, two limiting factors exist on the operation of the network. First, the main transmitter signal can create advanced multipath (pre-echo) in the overlapping coverage areas between the main transmitter and the repeaters. For creating pre-echo, the repeater's signal must be dominant in such overlapping areas. This may be problematic to the ATSC legacy receivers that are vulnerable to pre-echoes. Second, depending on the amount of feedback from DOCR transmitting to receiving antenna, there is a power limitation on the repeaters' output.

CRC has already studied, by performing various field tests, different applications of direct RF operation OCRs and their performance under different conditions, and has published the results [2,3]. This study focuses on the second configuration of distributed transmission network, which is "distributed translators".

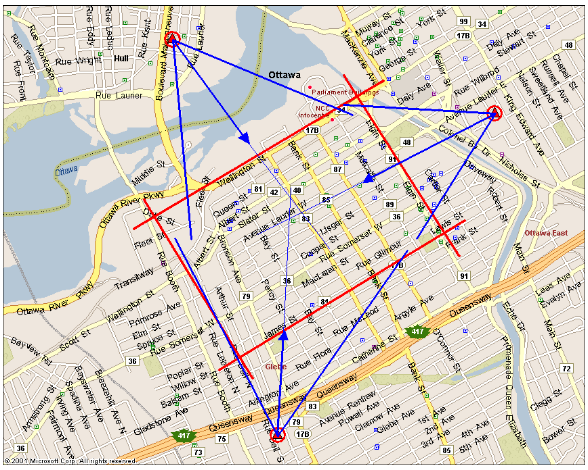
6.7.3 System setups and methodologies

The distributed transmission network under consideration by CRC consisted of three coherent translators. The translators received their input signal on channel 67 (788-794 MHz) from a medium power DTV transmitter having a tower height and EHAAT of 209 and 215.4 meters, and located at about 30 km south of Ottawa. This DTV transmitter covers Ottawa and its surroundings with an average ERP of 30 kW through a horizontally polarized omni-directional antenna system.

The translators converted the received channel 67 to channel 54 (710-716 MHz) through direct RF to RF operation. They were all frequency synchronized and their timing was adjusted to make them transmit with no delay with respect to each other.

The translators were installed on the top of three high-rise buildings in downtown Ottawa. They covered a common rectangular target area of approximately 1.66 by 1.14 km, and their output powers, which were between 15 to 25 Watts ERP (enough to cover the small rectangular target area), were adjusted to produce equal signal strengths at the centre of the target area. Figure 1 shows the relative locations of the three synchronized translators along with their overlapping target area. Also shown is the direction of transmission of the three translators output antennas and their 60º beam width. The main DTV station, which covers the whole Ottawa area including its downtown in which the DTx target area is located, is outside the map in the bottom right direction at a distance of 25 km from the centre of the target area.

Figure 1 (Case study Canada) – Ottawa distributed translator network. The rectangular target area is 1.6 X 1.14 km



6.7.3.1 Receiving conditions and reception points

The receiving conditions for these tests were intentionally selected to make a worst case scenario for the study. A single target area was selected for all three translators (see Fig. 1). In this way, the translators could create a lot of artificial multipaths (active echoes) in the target area. On the other hand, the downtown canyon, in which such target area was located, made the situation worse by creating additional static and dynamic multipath through reflections of each of the translator's signal from high-rise buildings and moving vehicles (passive echoes).

The measurement points were at the corners of the grids of a lattice covering the target area. A total of 59 points, at distances between 100 to 200 meters from each other were measured. For the measurements, which were made on the street sidewalks at about 1.5 m AGL, two types of antennas were used, an omni-directional antenna and a low gain directional antenna (usually used for indoor reception) with about 5 dB gain and 60º beamwidth.

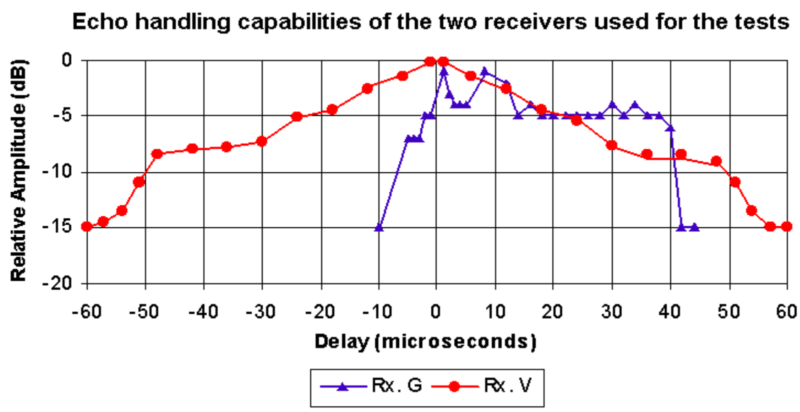
Both antennas were made active by connecting them to a low noise amplifier (LNA) of about 1.2 dB noise figure and 20 dB gain, and also a band pass (BP) filter installed on the same stand as the antennas.

6.7.3.2 Characteristics of the receivers used for the tests

For these tests, two types of receivers were used, a new prototype, and an older generation receiver. The new prototype receiver, as compared with the older generation, was capable of handling pre and post echoes with a much wider delay range.

Figure 2 shows the relative attenuation of a single static echo at different delays, at which the receivers are at the threshold of visibility (TOV). As it is seen, the older generation receiver (Receiver G in the figure) could operate with about –5 dB echo in the range of –3 to +40 µs. The new generation receiver (Receiver V in the figure), on the other hand, could handle pre and post echoes over a wider range. It was capable of handling –10 dB pre- or post-echo with a delay spread of –50 to +50 µs, or –5 dB echo in the range of –25 to +25 µs.

Figure 2 (Case study Canada) – Performance of the two receivers used for the tests



6.7.4 Test results

In the first phase of the tests, the feasibility of implementation of such a network was verified.

In the next phase of the study, measurements were performed in 59 points inside the target area. Table 1 shows the percentage of locations in which successful reception was achieved.

Table 1 (Case study Canada) – Percentage of reception points with successful reception

	DTx (CH-54)	
	New Prototype Rx.	Older Generation Rx.
Directional Rx. Ant	97%	54%
Omni-directional Rx. Ant.	71%	19%
	Main Tx (CH-67)	
	New Prototype Rx.	Older Generation Rx.
Directional Rx. Ant	93%	36%
Omni-directional Rx. Ant.	44%	10%

The table shows the results for DTx (CH-54) and also for the single distant transmitter (CH-67), using the new prototype and the older generation receivers, and also using directional and omni-directional antennas. As it is seen, the results are somehow better, under all circumstances, with the DTx network as compared to the single transmitter configuration.

Comparison of the results, however, can be made based on the type of the receiver, type of the receiving antenna, or type of coverage. What is quite evident is that under any condition, the reception situation is remarkably improved when the new generation receiver is used instead of the older generation receiver. Another major improvement can also be seen with using directional antenna instead of omni-directional antenna for both DTx and single transmitter. This has probably been due to the attenuation effect of the antenna on signals coming from the directions other than the main signal and acting as multipath.

Another important result that can be highlighted from this table is the fact that the DTx network, as compared to single transmitter configuration, has improved the situation also for the older generation receiver under all conditions (although not significant in all cases). The most significant improvement is when directional receiving-antenna is used. Under this condition, distributed transmission could improve the percentage of points with successful reception from 36% for single transmitter configuration to 54% for DTx network.

6.7.5 Conclusions

In this study, a distributed transmission (DTx) network, consisting of three coherent translators, was used to cover parts of the coverage area of a single transmitter. Two types of receivers and two types of receiving antennas were used and measurements were made in both channels corresponding to the DTx network and the single distant transmitter. The reception conditions were made very tough by choosing overlapping coverage area located in the hostile downtown environment for the DTx network, and also by making the measurements at 1.5 m AGL on the street sidewalks.

The results showed that the DTx network had a better reception availability than the single transmitter, especially when omni-directional receiving antenna was used.

The results also showed remarkable improvement in the performance of a new prototype receiver in the SFN environment, as compared to an older generation receiver that was used in the tests. This was because of the major improvement in the multipath handling capabilities of the new prototype receiver, which makes the implementation and operation of ATSC distributed transmission networks possible and reliable.

Another important result was the impact of even small directivity of the receiving antenna on reception. Directional receiving antenna, as compared to the omni-directional one, could provide successful reception for a greater percentage of the measurement points.

The test results also demonstrated reception improvement for the older generation receiver under SFN operation. However, because that receiver was only one generation older than the new prototype one, more tests are required to investigate the performance of the legacy receivers in a distributed transmission environment.

6.8 Case study: Germany

This case study deals with the switchover of terrestrial television from analogue to digital transmission in Berlin-Brandenburg.

The switch-off of the last analogue terrestrial frequencies in Berlin-Potsdam on 4 August 2003 marks the completion of the world's first switchover from traditional terrestrial TV transmission to DTT.

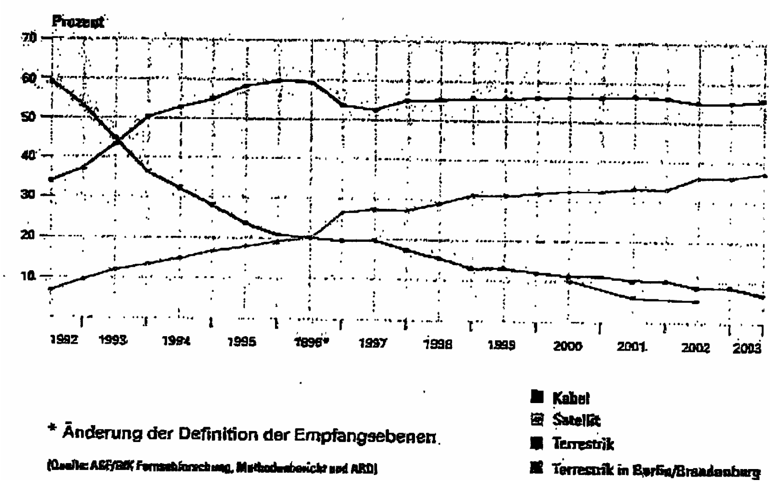
The results of this process provide encouraging findings to continue along this route.

The report below presents the switchover scenario, the experiences gained and the perspectives to be developed from it. Comprehensive documentation is under preparation.

6.8.1 The start-up scenario for the switchover

The decline of terrestrial reception

The number of homes receiving TV over the air has been going down continually in recent years. In national terms, the trend is as follows:



This decline could not even be slowed down by the above-average number of analogue services available in Berlin-Brandenburg where as many as 12 channels could be received terrestrially.

Before DTT roll-out, terrestrial reception was as follows:

- 160 000 homes with terrestrial reception only
- 90 000 homes with terrestrial reception for 2nd and 3rd sets
- of 1.8 million television households in the reception area overall.

The DTT pilot project and experiences with DTT all over the world

- DTT test operation since August 1997 in single-frequency networks in a joint pilot project of Deutsche Telekom, mabb and SFB.
- First frequency (channel 51, N-TV) switched from analogue to digital transmission.
- 16-QAM 2/3 modulation established as suitable transmission technology for achieving portable indoor reception.
- The failure of digital subscription (pay) television in the United Kingdom and Spain underline the fact that switchover must be undertaken with free-to-air television.

The legal framework for the switchover

Under the digital broadcasting initiative of the Federal Government and the German states, transmission should be completely digital by 2010. Under the specifications of the Telecommunications Act (TKG), television frequencies must be operated exclusively in digital technology as of 2010.

The switchover is a prime objective of the European Union's eEurope action plan. The states of Berlin and Brandenburg were the first regions in Germany taking such initiative: an early amendment of the interstate media services treaty governing cooperation under the Broadcasting Act for the public-sector broadcasting corporation (ORB) paved the way towards appropriate legislation for the switchover. At the initiative of the states, the Interstate Broadcasting Treaty governing broadcasting in all German states was also amended to permit all public-sector broadcasters to effect the technology changeover. Also section 52 entitles public-sector broadcasters to gradually discontinue analogue terrestrial transmission under certain conditions to allow for the build-up and allocation of digital terrestrial transmission capacities in a phased process.

Under section 52 of the Interstate Broadcasting Treaty, television services so far using analogue transmission capacities must be given preference when the first digital terrestrial transmission capacities are allocated. The interstate media services treaty taken out between Berlin and Brandenburg in addition requires the cable network operators after switchover to continue retransmission of services that had been awarded analogue capacities before.

Section 46 of the interstate media services treaty regulates the role and participation of the Berlin-Brandenburg regulatory authority, mabb, in the switchover process and entitles mabb to draw up special statutes governing the allocation of digital terrestrial frequencies. Under this statute, capacities permitting the transmission of broadcasting services, media services and other services may be decided upon and allocated jointly. The allocation can be effected under public law via a public contract. The mabb media council based its decision of 9 July 2001 on this provision.

In the Memorandum of Understanding agreed on 13 February 2002,

- The public-sector broadcasting corporations ARD, ZDF, RBB (successor to ORB and SFB as of May 2003),
- The private broadcasting services of the RTL group and the ProSiebenSAT.1 Media AG,
- Mabb

laid down the key elements of the switchover.

The concept for switchover

The switchover was scheduled to involve three stages:

- During stage one, at least one high-power analogue channel was to be switched to digital transmission to demonstrate the quality of DTT and to provide some orientation for the households affected regarding new receivers to be purchased.
- In stage two, the high-power transmitters were to be switched to digital signals; analogue transmission of all national commercial broadcasters would stop, and the public-sector services would continue analogue transmission only via lower-power frequencies.
- In stage three, all analogue frequencies were to be switched off completely.

Availability of receivers

To benefit from the switchover, consumers had to purchase a set-top box or an integrated TV receiver. Support from subscription (pay-TV) services or subsidies for the provision of low-cost set-top boxes were not expected to materialize.

The start of the switchover was therefore linked to the requirement for the receiver manufacturers and retail traders to offer basic receivers not exceeding 200 EUR in price at the start of the switchover. Several manufacturers met this prerequisite by the start of the switchover process.

Furthermore, VHF reception (Band III) had to be ensured, and the sets had to be more advanced compared to DTT receivers employed elsewhere.

6.8.2 The switchover in progress

Communication campaign

The communication campaign aimed at informing the homes affected by the switchover without yielding any negative effect on homes receiving television via cable or satellite. The homes affected had to be notified of the various stages of the switchover and their effects on television reception; they also had to be given objective details on the advantages of the various modes of transmission so as to help consumers with their decision on their future mode of television reception. Special information was required for DTT which was not available at the time at all.

Together with the television broadcasters, a communication concept was developed which was put into practice by the “Die Brandenburgs” agency.

The key media for communication was provided by the TV channels themselves: information spots and running bar information specifically devised for the campaign were intensively broadcast during the various “hot” stages of the switchover, reaching all affected homes in Berlin and Brandenburg.

In addition, the broadcasters also reported on the switchover in their local news and current affairs programmes.

The most cost-intensive measure was a letter sent to every home in February 2003 which clarified once more that only homes which receive television via roof antenna were affected by the switchover.

For information in shops and for supplementary information, leaflets, brochures and newsletters were developed; no cost-intensive advertising or poster campaigns were run.

The parties to the switchover process also cooperated closely with the Berlin tenants association and the local consumer associations. The product quality assessment board (Stiftung Warentest) tested receivers at an early stage and provided information on the developments.

During the switchover process, a joint telephone hotline was set up linking experts working for the broadcasters, mabb and GARV (the joint company of mabb, ORB and the Mecklenburg-Vorpommem regulatory authority promoting infrastucture). The hotline dealt with some 22 000 calls, and only 600 of the problems described could not be solved directly over the phone.

The campaign was supported via an internet website which had been designed in co-operation with Deutsche TV-Plattform (www.ueberallfernsehen.de)

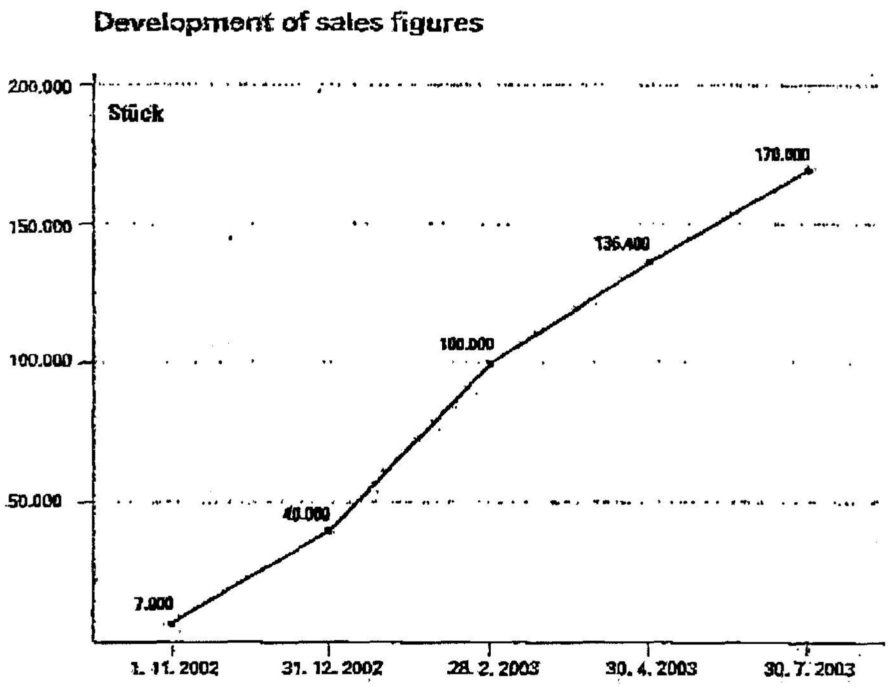
The costs of the communication campaign were covered by the broadcasters and mabb; they remained below the budgeted sum of 1.2 million EUR.

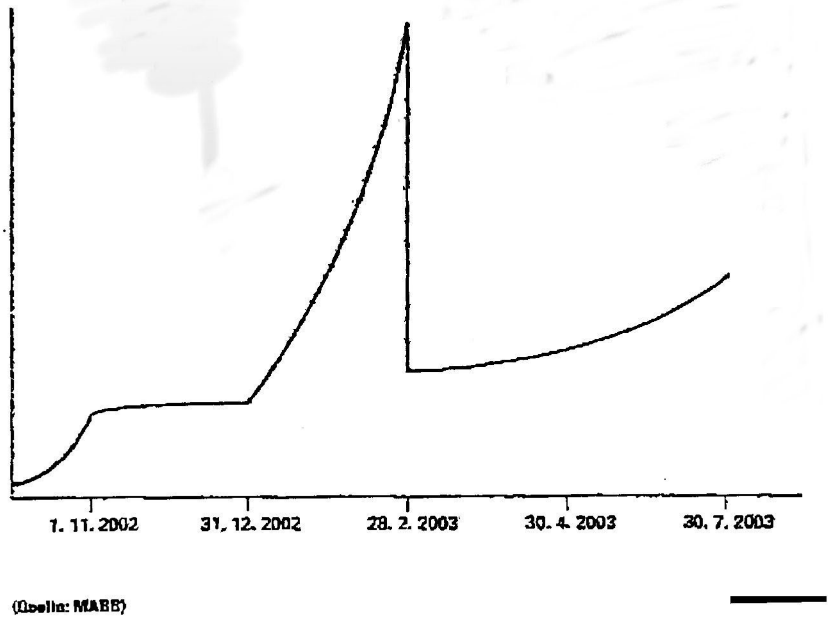
Receivers (set-top boxes)

The retail trade was informed about the switchover and its technical details in a series of information events conducted in spring 2002 by the Deutsche TV-Plattform (a cooperation of service providers, network operators, regulatory authorities and others) and the Berlin/Potsdam chamber of industry and commerce.

The range of set-top boxes offered in the shops exceeded expectations for this limited market.

The key factor for the development of sales was the main stage of the switchover in February 2003; thereafter, sales initially went down again but recovered subsequently.





The switchover in a socially acceptable manner

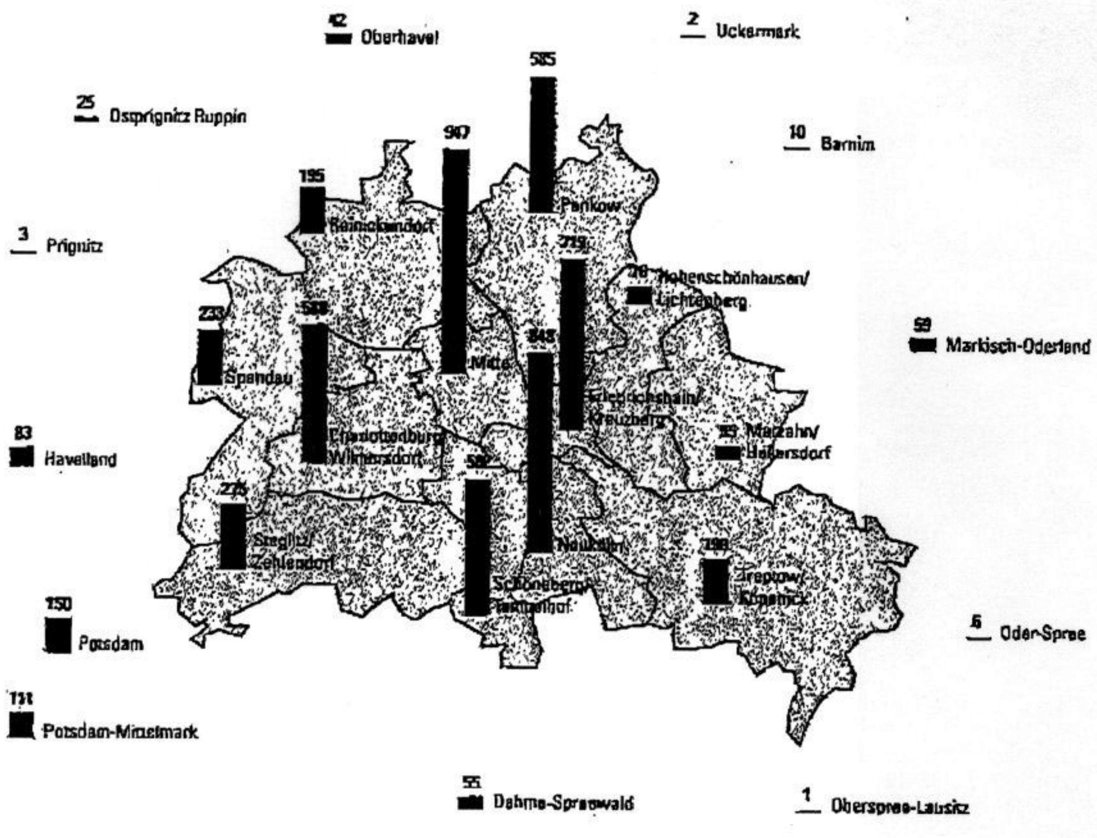
The parties involved in the switchover process were in agreement that a key issue to be resolved in the switchover process was how to make the switchover affordable also for homes with only a low income.

The receiver industry contributed towards this objective by providing sets for hire purchase, offering boxes at 8.50 EUR per month during the introduction phase to low-income homes. However, little use was made of this offer.

A special solution had to be found for homes entitled to a TV set under the German social security rules. Homes dependent on terrestrial reception were entitled to a set-top box. In an agreement with the social security services in Berlin and Brandenburg, mabb agreed to arrange for the low-cost provision of set-top boxes. The media council budgeted a maximum of 1 million EUR for this purpose on the provision that the social security services assume 25 per cent of the cost as their own share and also agree to take on assessment of who would be entitled to any support. Support was strictly limited to the switchover period and only covered homes that had previously received television via roof antenna only. The social security services also had to investigate whether cable or satellite reception might not provide a more economical option in each case.

The provision and distribution of set-top boxes and the billing were organized via Rundfunkhilfe e.V., an institution set up by the association of free welfare organizations (Freie Wohlfahrtsverbaende). It organized some 6 000 sets.

The distribution of the boxes showed a notable demand in the western districts and in Berlin-Mitte while in the areas more remote from Berlin and the cities in the state of Brandenburg demand was limited (see distribution map).



(Quelle: MABB)

Planning and operation of the transmitter networks

Mabb, as the institution in charge of arranging technical transmission capacities for broadcasting in the states of Berlin and Brandenburg, applied for the technical capacities required under the switchover agreement with the German Regulatory Authority for Telecommunications and Posts (RegTP).

RegTP conducted the procedure of frequency allocation under the Telecommunications Act (TKG) and initiated the necessary measures of coordination.

Close cooperation and agreement resulted in meeting the requirements of telecommunication legislation in good time prior to the respective stages of the switchover process. This had presented a specific challenge for the network operators who handed back licences for analogue transmission that had been allocated to them for an unlimited period, and had to face up to a completely new procedure.

Deutsche Telecom AG aligned the build-up of the transmission networks with its subsidiary T-Systems media Broadcast and the future users at an early stage. By securing the necessary funding and the provision of the technical components early on, the network operators T-Systems and RBB (formerly SFB) could keep within the tight schedule.

GARV with its expertize contributed to developing solutions which met the interests of the broadcasters in the most economical manner. First of all, two transmitter stations were established in a single-frequency network. Further transmitter locations could improve reception, but this would require considerable additional expenditure.

International coordination was helped by the understanding which other European States showed for the switchover deliberations, especially neighbouring Poland.

Switchover of cable networks, housing industry information

As cable network operators and operators of community antenna systems use a certain segment in the terrestrial transmission chain to feed the services into the cable networks or house distribution systems, some changes were also required in this delivery process. By switching to satellite reception and feeding digital terrestrial services into the networks following reconversion to analogue transmission, continued supply was secured for the homes connected.

Even before the switchover commenced, the issue was investigated in detail under the guidance of GARV; the housing community and the cable network operators were informed about the measures to be taken at an early stage. For the first time, too, transposition of digital terrestrial signals in analogue cable networks was employed, and any resulting problems analysed and solved almost without exception.

Most cable operators and housing companies coped well with these challenges; the number and scope of problems during switchover could thus be limited to the absolute minimum.

Funding the switchover

The complexity of the switchover from analogue to digital transmission from a technical angle is matched by the complexity of funding the DTT roll-out: communication and information are among the prime tasks of the regulatory authority and its partners, i.e. the public-service broadcasting corporations funded through the licence fee, and the commercial broadcasters which are financed through advertising revenue. Solving the issue of social acceptability of the switchover is a public duty to be fulfilled by the State. The reconstruction of the transmitter stations falls within the responsibility of the Regulatory Authority for Telecommunications and Posts which selects and licences the network operators in a tender process.

The licence fee revenue granted to the public-sector broadcasters also includes a certain share allocated to changes in transmission technologies: The calculation of the licence fee by the commission establishing the funds required by public-sector broadcasters for their operations (KEF) explicitly includes DTT. For the whole of Germany, the ARD network has an annual budget of 18.4 million EUR at its disposal while the funds for ZDF come to 9.2 million EUR per annum which are to be put towards the development of new infrastructures.

Unlike the public-sector broadcasters, the commercial broadcasters cannot bank on such funding options. For them, the switchover does not produce any additional income, but on the contrary might even result in a loss of audience shares. However, having the commercial services included in the overall DTT package was essential for attracting consumers to spend money on a new receiver.

Under the Interstate Broadcasting Treaty, the regulatory authorities can grant support to measures serving technical infrastructure from their budgets which are derived from a fixed percentage of the licence fee revenue. The switchover actually became possible subsequently as the commercial broadcasters handed back the licences allocated to them for analogue transmission. In return, mabb lends support to the commercial broadcasters for a limited period.

In its support, mabb adopted the guideline that the commercial broadcasters in all cases bear those costs that would have accrued from the continued analogue operation.

The support granted for a channel varies from 60 000 to 70 000 EUR per annum, depending on its technical design.

The two major commercial broadcasting groups, RTL and ProSiebenSAT.1 Media AG agreed to transmit their services for a minimum of five years via digital terrestrial technology, thus providing a reliable basis for consumers deciding on the purchase of a new receiver set.

Mabb also supports the switchover of BBC World and of FAB, the local commercial TV broadcaster, who have both also handed back their analogue frequencies at comparable conditions.

Some other broadcasters who had not so far been allocated terrestrial frequencies are also granted support for reasons of equality.

Allocation of capacities

The Berlin-Brandenburg interstate media services treaty allows for the allocation of capacities via the DTT statute issued by mabb to accommodate the specificities of digital transmission and the process of switchover from analogue to digital.

The capacities to be allocated to the public-sector broadcasting corporations and the commercial television groups can be awarded under public law as complete multiplexes, provided a minimum of two multiplexes are available for other broadcasters and for new applications.

Mabb put to tender the available capacities under a decision of its media council taken on 8 May 2002.

Experience to date has shown that there is no scarcity of capacities at present as many broadcasters who had previously not been allocated terrestrial capacities are currently not in a position to fund the additional cost incurred in digital terrestrial transmission.

Several applications were put on hold for the time being as they can only be realized in the next stages of DTT development.

The use of capacities by the subscription (pay-TV) service Premiere has not yet been decided. Another issue awaiting clarification is the question to what extent capacities will have to be provided for new applications and combinations of television services and other services. Several approaches to this effect incorporating mobile telephony providers have already been presented.

6.8.3 Experiences and findings gathered during the switchover process in Berlin-Brandenburg

The switchover took place at the right moment

DTT roll-out could not have been effected any earlier as receiver prices would have had a adverse effect on acceptance. Nor should the switchover have come any later, even though the digital broadcasting initiative envisages 2010 as the deadline for switchover.

The incentive for switchover decreases in direct proportion to the decline in the number of households receiving television over the air; the lower this proportion, the lower the interest of commercial television broadcasters in this mode of transmission. However, without the participation of commercial broadcasters, terrestrial transmission could only continue if public support were increased.

The acceptance of television broadcasters and consumers is the key prerequisite for switchover.

In any switchover process, the various interests must be balanced and mediated against each other. An attractive range of services for consumers must include programmes of both the public-sector broadcasters and the commercial broadcasters.

Without the switch-off of analogue signals and fast switchover, DTT would have little chance of being accepted by consumers and broadcasters.

Only by switching off some high-power analogue frequencies could the spectrum necessary to bring home to consumers the two key benefits of DTT be made available. Benefits include a sufficiently attractive range of services and portable indoor reception without the need to resort to a CATV system.

For the broadcasters, switch-off was essential to avoid costs from doubling as a result of parallel analogue and digital transmission (simulcast); the commercial broadcasters would not have been in a position to meet such expenses.

The available funds would not have sufficed for a longer simulcast operation or increased support for the commercial broadcasters; spending money in this way would also have been counter to the principles guiding the economic deployment of funds.

As a key for switchover, funding of commercial broadcasters dependent on advertising revenue must be resolved.

For the consumers, DTT holds attractions as it does not incur any additional expenditure, while for the commercial broadcasters terrestrial transmission is an expensive mode of transmission as, unlike in the case of cable reception, consumers do not contribute to the cost of service provision.

Additional revenue cannot be generated for the time being as DTT does not currently constitute an audience reach creating any interest within the advertising industry.

However, the commercial broadcasters should be interested in upholding the third mode of transmission as they can thus avoid becoming dependent on cable or satellite distribution alone, and can also develop new mobile and portable applications.

DTT is of special interest for the consumer and for the development of a broadcasting infrastructure which has some significance for the public at large. This is one of the reasons why public funds are put towards the realization of DTT.

Switchover is also justifiable as it contributes to an economic use of licence fee revenue.

For the terrestrial distribution of their services, the public-sector broadcasters spend a total of 305 million EUR per annum. However, the number of viewers reached over the air is continually going down. Unter the Interstate Broadcasting Treaty, public-sector broadcasters may switch to digital transmission, but they must not suddenly cease analogue transmission altogether. The transition from analogue to digital transmission will only work in conjunction with the commercial broadcasters following along the same route.

The world of analogue transmission was characterized by the separate development of the various infrastructures; as a consequence, no overall funding concept for digital transmission has as yet developed. Instead, the public-sector broadcasters follow their own approach while the regulatory authorities support the funding of the infrastructures to be used by commercial broadcasters. Looking at infrastructure development as a whole, however, it would seem that re-allocating the money earmarked for analogue transmission until now could be sufficient to completely fund the digital infrastructure provided that the concept of overall terrestrial coverage everywhere and the strategy of closing gaps in terrestrial transmission in rural areas are given up; satellite transmission has long since made this approach obsolete.

For consumers it is worth it to switch over.

Even though analogue services were switched off, the switchover resulted in less protest than had been anticipated.

The switchover quite deliberately did not bank on parallel (simulcast) operation which would have meant that analogue transmission was only discontinued once 90 per cent of homes were supplied with digital terrestrial TV. As the experience proves, switch-off is accepted by a considerable number of viewers provided that adequate substitutes are available.

It was possible to convey the idea that the third mode of transmission can only be secured through modernization. Switch-off without anything to compensate for it would probably not have met with acceptance.

The added value of receiving more services for which the licence fee is paid which previously, however, were not available terrestrially due to the scarcity of transmission capacities (e.g., Arte, 3Sat, Kinderkanal, Phoenix), as well as the improved quality of reception (independence from CATV systems, portable indoor reception) were sufficient to bring the benefits of DTT home to consumers. Numerous comments by viewers on these services as well as on those not available (e.g., BR) refute the claim that the viewers traditionally receiving television over the air would be content with fewer services – the opposite is the case.

Digital receivers were accepted despite the additional expenditure, and even though they currently still include some disadvantages compared to analogue reception (additional cost of set-top boxes, one additional set per TV set or video recorder, switchover problems with the video programming system, VPS).

Consumers appear to accept that more services means more expenditure, be it in the form of ongoing fees as is the case for cable reception, or in the form of the one-off expense incurred for a satellite dish or a set-top box for digital terrestrial reception.

The development of the receiver market

The receiver market is characterized by stationary receivers largely based on satellite receiver technology. Within a very short time, lively competition ensued, resulting in a clear drop in prices from which consumers benefit.

Switchover in Berlin was possible only because the synergies within the DTT range of products permitted low-cost stationary receivers to be put in the shops, and because Berlin could draw on the experience gained in other countries.

Prices in special sales promotions dropped to less than 100 EUR per set-top box. In the decisive period, retailers supported the introduction of DTT with large-scale advertising campaigns.

As is the case for the first introduction of any new technology special difficulties were also expected for DTT. The equipment could only be tested after it had been brought into the market. A certificate "suitable for DTT" did not exist. The sensitivity of receivers or room aerials even under problematic conditions of reception could only be tested once the technology and the sets had been introduced; depending on the various types of receiver, reception varies in quality. The ease of operation also differs, as does the software employed, resulting in certain problems during switchover and the necessary re-adjustment of channels.

It proved impossible to arrange for joint communication measures for the receiver industry; experiences regarding consultation of the retail trade differed.

Considering that a large number of households affected by the switchover were not prepared to acquire the latest sets developed and had little experience in the use of digital equipment, the number of complaints and problems remained remarkably small.

For most consumers, the additional services available in good quality proved satisfactory, and the electronic programme guide (EPG) is accepted as a useful add-on. For additional interactive services it will be necessary to align the specifications of receivers to a greater degree.

Another issue awaiting solution is the downloading of new software over the air. This service is required as not every household has access to the internet or can download software via the world-wide web.

Reservations about digital television were allayed as a result of the experiences gained during analogue-digital switchover in Berlin-Brandenburg. Until then, digital television had been associated with subscription (pay) TV and the d-box in Germany and had been rated accordingly critically. From this change of assessment, the digitization of other modes of transmission could well benefit.

The fast switchover has opened up the entire frequency spectrum for digital services, for more television channels and for other applications.

Digitization provides an opportunity to the present users of frequencies to extend their range of services.

At the same time, access to terrestrial capacities is now open to other service providers who previously did not transmit their services terrestrially.

Apart from broadcasting services, other applications, and in particular interactive services, can be developed.

Competition in this route of transmission is thus increased.

Competing infrastructures

Terrestrial transmission is gaining in attractiveness and thus presents an alternative to cable reception above all in densely populated areas where satellite reception is frequently hampered.

Consumers welcome such an alternative so as to avoid becoming dependent solely on cable reception.

By comparison to terrestrial reception, cable offers certain advantages, especially the higher number of services available and the options for interactive applications.

Furthermore, even if not digitized, cable has the benefit of comfortable and easy use, a major factor especially for elderly viewers. However, this comfort presents an impediment for the development of new receiver technologies. Digital satellite reception and digital terrestrial reception will be the decisive factors for technology standards. Competition must be an incentive for cable operators to advance the benefits of cable even if the margins for price increases without increased performance have become smaller.

A more detailed range of products meets the demands of consumers: many consumers accept fewer television services, and reception via second and third sets will rise.

Experiences gathered during the communication campaign

It took considerable time and effort until a communication concept had been developed that was shared jointly by all television service providers and mabb, especially since there were plenty of varied ideas, but no previous experiences to draw on.

As a key starting point it was agreed that the communication campaign should not focus on promoting a new product, e.g. as a competitor to cable transmission, but should rather concentrate on informing the public about an impending change of technology affecting many homes. It appeared appropriate to replace the term "DTT" by "Everywhere Television". However, this term turned out to be slightly misleading as the concept also requires some activities by consumers in providing suitable conditions for reception.

What was atypical by comparison to other countries was that in Berlin-Brandenburg, there was no platform operator as is the case for cable networks or the ASTRA chain of satellites, or Digitenne which promoted the new mode of transmission in the Netherlands.

Experience to date on migration: terrestrial reception attracts younger audiences

Trends observed so far show that terrestrial reception attracts younger audiences and holds a strong position for second and third sets in the home. A large part of terrestrial households thus kept to terrestrial reception. Homes switching to cable reception included a large share of older audiences, partly because this proved more comfortable, but mostly because housing associations discontinued terrestrial reception.

On the other hand, however, good DTT reception is gaining in significance as an alternative for those consumers who are dissatisfied with the services available via cable. Price increases in this context can play a part in this as much as the service provided by the cable operators and the development of the range of services available via cable.

More findings are expected from the research conducted by ARD and ZDF on the switchover.

It will, however, take another two to three years for a comprehensive picture to emerge on how attractive terrestrial reception can be for the consumer, especially since portable and mobile reception are only just getting off the ground.

Experiences gained with regulation and mediation

The flexible framework provided by the Berlin-Brandenburg interstate media services treaty and the DTT statute supported the switchover process. The regulation available for the analogue world would not have been sufficient as the service providers using analogue frequencies had to be offered incentives to switch from analogue to digital transmission. Agreements in the form of a contract proved particularly suitable to meet this requirement as they can accommodate all issues requiring regulation both concerning the allocation of capacities and the support mechanisms as well as the schedules.

Mabb proved to be well capable of mediating among the various interested parties as it is responsible for capacity allocation both to public-sector broadcasters and to commercial broadcasters and conducted intensive research of all aspects of digitization.

The fast decision-making processes proved to be of particular benefit in this context: the mabb media council had long decided on co-funding measures covering communication and social acceptability while the equivalent commissions of ARD and ZDF could not conclude their deliberations in good time.

6.8.4 Further perspectives

Switchover is only the start of a new development

During the switchover process, the prime objective was to get consumers to accept the switchover even in the light of some negative side-effects including the switch-off of analogue frequencies and additional costs for new receivers.

This objective has been fully achieved as a result of the creation of an attractive alternative for stationary reception.

Without this basis, new applications and new target groups cannot be generated; the switch-off of analogue frequencies would not have been accepted without attractive substitute solutions.

Now the objective must be to promote the further advantages of DTT including portable and mobile applications in conjunction with the further development of digital reception technology.

In order to provide sufficient thrust in this, other city areas in Germany must follow the Berlin example.

Some details of the next stages of development: Development of stationary receivers and aerials

The increasing performance and the performance range of set-top boxes in the satellite sector will also present advantages for DTT ; this includes hard disks for storage.

The sensitivity of reception of receiver equipment can also be expected to improve. Regarding DTT this will relate above all to the development of aerials (rod antennas). Activities in this field have so far been limited as there are no synergies with the satellite sector.

Aerial technology will become even more important when mobile and portable reception increases.

Consideration should be given to certifying receivers prior to further switchover processes so that additional applications can be warranted to be available via all receivers.

Minimum standards concerning sensitivity of reception and ease of operation, e.g. for channel tuning, should help to reduce problems during switchover. Special consideration should be given to devising receiver equipment in a manner also suited for operation by persons with disabilities.

Promotion of interactive uses through the multimedia home platform (MHP)

Because of the wide range of receivers on offer and the development of a purchase market, an open standard will be required to ensure that receivers are suited to interactive services. MHP presents such a standard.

The market for DTT, however, will only provide the necessary economic basis for new services in conjunction with the satellite market.

It would appear obvious, therefore, to introduce MHP together with a technology also permitting addressing and billing procedures.

Here too, appropriate agreements relating both to the satellite market and the DTT market would appear to be the best way forward.

Portable receivers

Portable sets with integrated receivers and aerials can bring across the key advantage of DTT, namely the reception of television via a portable set in different locations.

Price reductions as experienced with flat screens in combination with integrated receivers could already allow television to be watched in many locations where it has so far never been watched, e.g., the kitchen or a sailing boat.

In the medium term, measuring audiences watching TV on portable receivers will gain particular importance as the technology employed so far is linked to stationary receivers; portable reception will be of special relevance for commercial broadcasters.

Mobile applications – development of DTT-H

On the basis of DTT, new transmission processes can be developed which are particularly suited for reception on hand-held sets (PDA and mobile telephones). The smaller displays and new compression technologies permit larger video streams to be transmitted than has been the case for stationary reception so far.

The frequency spectrum which has become available as a result of the switchover to DTT permits such new applications to be tested and used in hybrid structures in conjunction with mobile communication networks.

The interconnection to mobile communication networks also offers the advantage of billing, thereby opening additional funding options for terrestrial transmission routes.

Digital broadcasting transmission routes permit the transmission of audiovisual content at low cost, especially content attracting large audiences (e.g. live transmission of football matches). The share of the fee to be employed for funding content is far higher than in the case of 3G applications which also incur high costs of transmission for broadband applications. This presents another incentive for the development of new content for mobile transmission.

National perspectives for DTT

The acceptance with which the switchover in Berlin-Brandenburg has been met is a sound basis for continuing switchover in other major city areas in Germany.

Frequency problems could thus also be resolved if city areas are addressed first regarding DTT switchover.

The switchover elsewhere could draw on the experiences gained regarding communications and social acceptability.

To agree on a national concept solving the entire range of issues concerning terrestrial transmission and its funding, however, would not appear to present a realistic option at present.

Switchover in major city areas in Germany will itself provide new incentives for the next steps and will enhance the development of the market especially by offering opportunities to consumers to determine the future developments via his or her choices.

The opportunity of a fast switch-off as proven during the DTT roll-out in Berlin-Brandenburg is a precondition for the future of digital television, otherwise the result would be problems similar to those encountered with digital audio broadcasting (DAB).

Assessment of the experiences for other digitization processes

The experiences gained during the switchover in Berlin-Brandenburg may lend support to the identification and possibly even the solving of problems which might occur during other digitization processes.

While digitization of satellite transmission is making progress as it is driven by the market, digitization of cable networks is still hampered with major problems as is the digitization of audio broadcasting (DAB).

The switchover in Berlin and Brandenburg has shown that it can be worthwhile to venture off familiar paths. Media politics should take courage from the experience and should promote digitization in other regions as well.

Now the next challenge has to be faced: the development of portable and mobile applications and their connection to mobile communication networks.

6.9 Case study: Guinea

6.9.1 Legal and regulatory aspects

It has to be acknowledged that analogue radio and television broadcasting are not very developed in certain African countries, for example the Republic of Guinea, where radio broadcasting was introduced only in 1952, and television in 1977.

The transmission medium initially used was the radio-relay network, constructed in 1977.

Today, this network, operated by the Department of Posts and Telecommunications and digitized to the tune of 85%, does not carry television and radio signals owing to the advance of satellite broadcasting, which is favoured by the Government. However, we are convinced that the rapid development of radio and television broadcasting will of necessity involve digitization through liberalization of the audiovisual sphere.

Legal and regulatory framework for DTT

In the Republic of Guinea, the tools and infrastructures conducive to the rapid opening up of digital radio and television broadcasting are to be found in different sectors, with much of the equipment (radio and television transmitters, studios) being administered by the Ministry of Information, while other equipment (shortwave and medium wave radio transmitters and terrestrial radio-relay transmission facilities) is administered by the Ministry of Posts and Telecommunications. The Government would be better advised, with support from the development partners, to group the various communication media under the same authority, pending the opening up of the audiovisual sphere.

6.9.2 Technical aspects

Two alternatives may be envisaged for the migration from analogue broadcasting to DTT:

- close down the analogue system and construct an entirely digital network,
- deploy a hybrid system (analogue and digital).

The second option would seem to be the most appropriate for developing countries. It involves using the existing analogue network with a certain amount of refitting and the construction of a number of sites. However, the paramount requirement for making the DTT network more operational is a redistribution (replanning) of the frequencies used, this being the task of the regional radiocommunication conference (RRC) over the coming months.

Furthermore, the fact that our States currently use the radio-relay network for their radio and television signals leads us to recommend, for those countries that share a common border, that they jointly replan their frequencies and select the same digital television system, namely DVB-T, which is technically more adaptable than the ATSC(A) and ISDB-T(C) standards. The B(DVB-T) standard is less costly and more advantageous to developing countries during the transition period. This will allow for more fruitful regional consultation aimed at harmonizing the technical facilities to be used when introducing digital broadcasting equipment.

6.10 Case study: Russian Federation

Strategy basics for transition from analogue to digital broadcasting within an individual region (based on the experience of introduction of DVB-T broadcasting in the Primorsky region of Russia)

Modernization of a regional broadcasting network aims at updating the transmission firmware of the TV and radio broadcasting network in a region, expanding the range and list of services provided by the broadcasting operator to the users, increasing revenue for the operator and effecting a phased transformation of such an operator into an information package provider for the region allowing both commercial and social problems to be solved.

6.10.1 Overall strategy of updating the regional TV and radio transmission network and transition to digital broadcasting in the region

As a rule the degree of wear of analogue transmitters operated in the region is pretty high. The useful life of many transmitters is already over. Replacement of worn-out analogue transmitters by new analogue equipment appears senseless both from the technological and economic point of view, as in the transition to digital broadcasting it will be necessary to replace such new transmitters again with digital ones, this time long before the end of their useful life. Besides, one cannot see any ways of compensating for such replacement costs as analogue broadcasting in principle cannot support the new information services and products that the population would be prepared to buy and that could generate additional revenue for broadcasting operators. In this connection it seems worthwhile making the transition to digital broadcasting in the region without delay.

It is evident that transition to digital broadcasting should be effected within the framework of current frequency arrangements, that is digital TV programmes should be broadcast in the same frequency bands as analogue broadcasting formerly. This means that overnight transition to digital broadcasting should be accompanied by stopping analogue broadcasting of the same programmes within the coverage area where such transition takes place.

It goes without saying that overnight transition to digital broadcasting is not possible without equipping the population with digital receivers, i.e. subscriber set-top boxes (STBs). Transition to digital broadcasting can only be effected provided that every subscriber has such an STB, so that in the transition process no small group’s interests suffer. A broadcasting operator is not responsible for the provision of STBs to the population. Without going in detail on the organization of such provision one should mention that this problem must be solved through local funding under a comprehensive target programme implemented by the regional administration with the help of private investments. Thus the financial burden should be distributed between the commercial structures of the region the overwhelming majority of which is interested in new advanced interactive multimedia infocommunication services and products (including e-commerce and e-banking systems) supported by digital broadcasting. Introduction of such systems within a united regional information system (to be described below) may give a powerful impetus to business development in the region with the corresponding growth of commercial structures' turnover and revenues.

As for providing STBs for digital broadcasting to the population, this should be done according to a uniform schedule approved by the administration and coordinated with the broadcasters in one transmitter broadcasting coverage zone after another. Under the schedule, STBs should be provided to all rather than part of the people residing within one coverage zone, then another and so on. This will ensure the possibility of making a final transition to digital broadcasting in the region successfully. The STBs themselves are multipurpose interactive terminals capable of supporting a wide range of modern interactive information services and products besides broadcasting.

It is clear that transmitters replacing the old worn-out analogue ones should be hybrid, i.e. equally capable of operating both in analogue and digital broadcasting mode. At the first stage such a newly installed transmitter will operate in analogue mode. Later on when the population in the coverage zone is 100% equipped with STBs the transmitter will go over to digital mode with the DVB-T modulator switched on and the driver replaced (it is desirable to have both devices supplied in a complete set with the transmitter). It goes without saying that at the first stage the transmitter will broadcast only those programmes that used to be broadcast for the given coverage zone in analogue mode. Thus the next problem that arises is of most importance for urban areas where several TV programmes can be received within one coverage zone. In each broadcasting zone several analogue programmes broadcast by different transmitters may be received. Digital broadcasting is multiprogram, i.e. one digital transmitter will broadcast all those programmes that used to be broadcast by several analogue transmitters. Thus only one "head" analogue transmitter should be chosen out of the group for the coverage zone to be replaced by hybrid equipment. The transmitter should be connected with MPEG-2 signal feeder lines for all the TV programmes broadcast for the given coverage zone. All the signals should be joined together in a multiplexer into an MPEG-2 transport flow and fed into the DVB-T modulator. After this the transmitter may be switched over to the digital broadcasting mode and the analogue broadcasting of other transmitters may be stopped and dismantled.

It is clear that transition to digital broadcasting should entail an increase in the number of programmes provided to the population. As a result the situation should emerge when the regional programme package (i.e. all the programmes that are currently broadcast to at least part of the population of the region) will be accessible to every TV viewer. Of course with time the package should be expanded gradually with new commercial programmes (including pay programmes) and with free regional programmes of social and informational importance. To achieve this it is necessary to solve the problem of constructing a full regional network of TV programmes supply and distribution, i.e. when each programme received in the region via satellite channels or produced in the region itself would be supplied to every transmitter (or a group of transmitters) operated in the region. The problem can be best solved on the basis of a fibre-optic line laid in the region and running through its major populated areas. Fibre-optic line branches, i.e. TV programmes supply lines to other populated areas of the region, should be based on the exiting radio relay lines or MMDS systems. Moreover the radio relay lines must be updated to transmit digital data streams. This can be done through using modems and MUXes ensuring the transmission of digital data streams along the existing radio relay lines at the rate of 51 Mbit/s. The equipment will digitize the radio relay lines and at the same time the UHF equipment installed will remain intact. In many cases MMDS systems can also be used to bring digital broadcasting programmes to home cable networks. Naturally to expand the digital broadcasting programmes package broadcast to the population it is necessary to install some additional digital transmitters. However it is important that reception of digital broadcasting programme packages from several DVB-T transmitters by outdoor antennas in many cases may be ensured without amending the existing home cable networks.

The regional programme package may be expanded both through increasing the number of programmes made up in the region itself and through receiving more programmes via satellite communication channels.

6.10.2 Stages of comprehensive modernization of the regional TV and radio broadcasting network

Thus with the above approaches the following stages of comprehensive modernization of the regional TV and radio broadcasting network for transition to digital broadcasting can be defined:

– distribution of DVB-T STB to the population. STB manufacture funding may be effected within a target programme of the regional administration funded by regional investors. The STBs should be multifunctional interactive terminals supporting a wide range of modern multimedia services and products along with broadcasting;

– choosing a "head" transmitter out of the operating ones in each broadcasting zone to be replaced by a hybrid unit (with analogue broadcasting at the initial stage) with digital signals of all the programmes broadcast in the area fed to the latter;

– starting digital DVB-T broadcasting of those programmes that used to be analogue from the head transmitter, stopping analogue broadcasting and dismantling all the other transmitters in the broadcasting zone with the process going on in one broadcasting zone after another as these are ready for the change;

– constructing a regional TV programmes supply and distribution network on the basis of fibre-optic lines and digital radio relay lines, MMDS and cable lines used in the "last mile" section;

– as the regional distribution network is expanded bringing the regional TV programme package (i.e. all the programmes coming to the region via satellite channels and all the regional programmes) to each populated area in the region, with further expansion of the range of such programmes, including new regional ones (regional TV, commercial programmes); installing new DVB-T transmitters;

– on the basis of digital TV broadcasting, organizing data transmission (including web and web-type multimedia services) from the very beginning of digital TV broadcasting to provide to the population modern infocommunication services and products, both socially-oriented and commercial;

– introducing interactive products from the very beginning of digital TV broadcasting, primarily web and web-type services on TV broadcasting basis;

– constructing in the region a united interactive information multimedia regional network on the basis of subscriber's STB with an interactive platform specially designed to take care of the region's needs and interests and a uniform system of conditional access chosen upon agreement reached between digital broadcasting operators.

6.10.3 Further development of the TV and radio broadcasting transmission network in the region, expansion of the range of services and network functions through interactive servicing and provision of multimedia services

Transition to digital broadcasting is not the end of TV and radio broadcasting transmission network modernization. It goes without saying that more TV broadcasting programmes will bring more revenue for broadcasting operators. However, the largest source of higher revenues is in the sphere of provision of a wide range of modern infocommunication services and products on the broadcasting basis to corporate and individual users. Technologically this can be achieved through encapsulation of multimedia data streams (including web and web-type services data) into TV broadcasting digital flows. Reception of the above services and their data display on the TV screen will be done with the help of digital TV broadcasting STBs. The same STBs with their software and firmware support return channels organized on telephone lines (on the basis of built-in dial-up modems) or with xDSL facilities or, provided there are home cable lines, HFC (hybrid fibre cable) on the basis of the DOCSIS standard (built-in or external DOCSIS modems connected with the STBs by Ethernet interface).

6.10.3.1 Overall description of information and interactive services and products based on digital TV broadcasting. The initial stage of introduction of the services in the region

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 a coded signal that requires using smart cards and conditional access systems. Private companies leasing equipment from the operator may provide such services to the population under subscription for pay packages. Moreover the possibility of free reception of the social programmes package (both national and regional) by the population remains.

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

In the towns of the region with sufficient telephone penetration, interactive systems may be deployed on the basis of a return channel on a telephone line. A return channel can support various e-commerce services, on-line shops as well as rating votes and population polls that are important socially and may be needed by the regional administration. At the same time high-rate access to the internet on dedicated digital DVB-T channels may be provided. For this a TV viewer will 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 after appropriate reformatting and rescaling of text and graphic objects in 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 the 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 or her age, education and social status to be a full-scale member of the global information infrastructure without buying a PC, just with the help of a familiar TV set. The digital TV broadcasting STB supports the internet access and e-mail functions.

At the next stage of deploying a digital TV broadcasting system in the region it becomes possible to extend the interactive services to remote rural areas with insufficient telephone penetration. This becomes possible through using return channel cordless DVB-RCT technology.

6.10.3.2 Construction of a united interactive multipurpose information system on the basis of digital TV broadcasting in a region

If there are return channels, the following interactive infocommunication services may be provided on the basis of digital TV broadcasting to corporate and individual users:

- access to the internet without using a PC;
- e-trade;
- e-commerce;
- management of a bank account, including execution of commercial transactions at a distance using a digital signature;
- e-system for ordering municipal services;
- communal utilities payment e-system;
- services base on "video-on-demand" technology;
- cottage industry e-systems;
- e-health;
- e-learning systems;
- virtual CD-ROM;
- web games.

All together the above-listed information services may form a united 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. It makes sense to shape such systems on a regional basis. For this there should be in the region data formation centres for 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.

Without going into detail concerning the construction and functioning of such a system it is possible to point out its major sources of additional revenues for the operator. These include among others subscription fee charged on the basis of a 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 analogue 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 a poll may be repeated in certain periods of time, e.g. annually, to identify the changes, if any). The questionnaire aims at establishing what type of advertising should be supplied to the subscriber. The questionnaire is based on

multiple choices. A given consumer index is assigned depending on the choice of answers. The index is forwarded to the operator's server and further on is used to identify the advertising materials to be supplied to this subscriber.

2) Mediametrics of TV programmes. An STB registers each switch over from one TV channel to another and certainly the viewing time on each channel. Periodically (say, once a day) the obtained viewing data is forwarded to the operator's server. The function allows calculation of the exact rather than approximate rating of TV programmes.

3) Advertising mediametrics. Each payment for goods and services effected by a subscriber with an STB (supporting the e-payments 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 analysed. This function is necessary to appraise the effectiveness of advertising materials.

It is clear that with these functions the operator of an interactive information system obtains data of vital importance both for TV companies (programme ratings) and advertisers (much higher effectiveness of advertising thanks to its target character, information about the effectiveness of advertising materials). This enhances the attractiveness of the system for the TV companies and advertisers and affects the operator's revenues accordingly.

Another important source of revenue for the operator is payments by commercial structures selling goods and services within the framework of the e-trade system, as part of the system as a whole. The e-trade system is in great demand for commercial structures as it enables these to increase significantly their sales. A new market is open to the sellers – electronic retail sales with immediate payment for goods and services in non-cash form via e-banking.

TV viewers may choose the goods via the on-line shops system in which they may view video clips of the goods, order these to be delivered to their homes or not and pay for them with the help of their smart card. Foreign practice confirms great success of such projects as in addition to convenience and time saving the customer pays less for the goods than in traditional shops (thanks to lower seller's overheads and non-cash payments) and due to that fact that e-payment systems in closed digital TV networks are more reliable than those on the internet.

If the above regional interactive information system based on digital broadcasting is established in a region as a next logical step after overall transition to digital broadcasting in the region, it would also be logical to base the system of subscription fees on a uniform conditional access system. It goes without saying that such a system should have an open (socially oriented) component and a commercial component and subscription fees will be charged only for services provided by the commercial component.

6.11 Case study: Computer-aided equipment for DVB-T/UMTS analysis networks

In lots of cases, radio planning becomes difficult when high density and urban sites are used. Today, regulatory bodies and operators have a limited choice of equipment available to make a good analysis and reporting of the radio planning efficiency with regard to the DVB-T broadcasting and UMTS/IMT 2000 networks .These equipments are monochannel equipments, so they do not have sufficient sensitivity or signal separation capacity to identify all signals having a significant impact on the network performance. A up-to-date equipment named ANTIUM (European Initiative) is able to detect and identify such signals by using a multichannel equipment, based on the reception on a multi-antenna array, associated to high-level multichannel algorithms. The requirements of the ANTIUM equipment is to detect all base stations or DVB-T transmitters having a significant impact on mobile performance that is:

– DVB-T: transmitters such as C/I = –20 dB.

– UMTS FDD / TDD: base stations with a P-CPICH Ec/I0 as low as –25 dB,

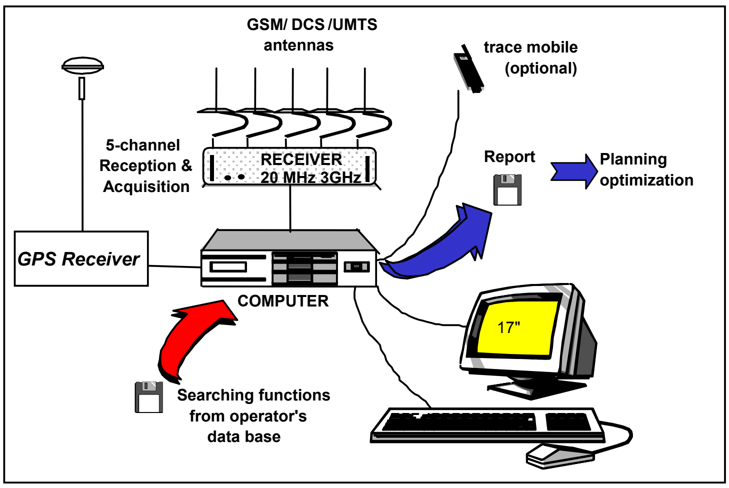
The ANTIUM tool can be used to analyze the interference situation (such as pilot pollution for UMTS, co-channel interference, adjacent channel interference due to another operator network or interference at a country border) at specific points where problems were previously detected.

The ANTIUM equipment generally installed into a mobile, includes:

- a *N*-antenna array (*N* = 5),
- a multi-channel receiver,
- a PC containing acquisition and command boards,
- a GPS system for outdoor measurement location,
- a trace mobile (UMTS / GSM/GPRS).

The operator can introduce its own network database. The analysis results are stored in report files that can be used afterwards by the operator for planning optimization or by regulators.

Figure 1 (Case study DVB-T/UMTS) – Main components of the ANTIUM tool



DVB-T network

The DVB-T interference analysis by ANTIUM provides the list of DVB-T transmitters sharing the analysed channel with their identifiers (TPS information) and their physical characteristics (level, *C*/*I* and Channel Impulse Response). ANTIUM also offers other features such as the detection of an analog TV signal for DVB-T.

The interference analysis allows to detect DVB-T transmitters for C/I down to –30 dB. The sensitivity is at least equal to –92 dBm without interference and to –90 dBm with interference.

When a DVB-T reception problem occurs and is detected at a given location, the first thing to do is to move to this place with a measurement vehicle. There, one has to check the sound and image quality to check if this problem exists. One then checks the field level of the useful signal. If this level is above a predetermined threshold, the problem is certainly due to an interference that has to be identified, and the ANTIUM equipment has to be used for this identification. When using ANTIUM, the technician has to provide some information to the equipment such as the central frequency of the channel, the configuration of the OFDM signal (mode, guard interval). He also has to take into account with the polarization of the antennas.

UMTS/DVB-T co-operation

Another point is that connection and co-operation of both UMTS and DVB-T systems can be envisaged in the mean term in dense areas where a user with an adequate terminal can select the best network to deliver the wanted multimedia content. In some convergence scenarios, the content request will be carried by the UMTS network up-link, whereas the requested content can be provided by either UMTS or DVB-T forward (or downward) links depending on best balance criteria between networks as content length/transmission duration, traffic situation, QoS considerations, costs, etc.

We can envisage networks cooperation only at the service level, the radio access networks having their own band allocated, or also at the spectrum allocation level. One can then think of spectrum sharing and dynamic spectrum allocation. Before making a practical use of these concepts for UMTS and DVB-T, one will have to face regulatory as well as technical problems (co-channel, overlapping channel and adjacent channel interference, difficulty of changing quite often the frequency of a DVB-T transmitter, terminal having to deal with RF immunity, large band-pass of the antenna, increased power consumption and a more complex synchronization process). Although originally designed for intra-system interference and known frequency allocation, the ANTIUM equipment turns out to be helpful also for inter-system interference analysis. More specifically, consecutive co-channel interference analysis and indirect adjacent and overlapping channel interference estimation can be performed with the current ANTIUM equipment. Some specific extensions like a frequency scanning and energy detection device, a demodulation and inter-system interference cancellation module for simultaneous co-channel interference analysis, direct adjacent and overlapping interference estimation algorithms and common broadcast channel detection could even increase the value of ANTIUM for the operators.

Let us just recall here that the UMTS FDD interference analysis by ANTIUM provides the list of the UMTS base stations sharing the analyzed channel with their identifiers (scrambling code, MCC, MNC, CI) and their physical characteristics (level, Ec/I0 and Channel Impulse Response). The interference analysis allows to detect BTS for P-CPICH Ec/I0 down to –30 dB. The sensitivity should be at least equal to –116.7 dBm (P-CPICH level) with one interference.

Conclusion

The ANTIUM measurement equipment provides a very good means to assist network operators or regulators facing the challenge of dynamic spectrum allocation and system convergence issues envisaged for future development of broadcasting and mobile radio communications systems.

Key objective of ANTIUM system is to forecast a future use of the equipment in multi-standard high rate environment. To target a great number of users, ANTIUM system has to be a multi-standard device. The developed ANTIUM tool will then become an open platform where different wireless systems operating in different bands can be treated. Today, ANTIUM deals with 2G (GSM/DCS/GPRS), UMTS FDD, IS95 and

DVB-T and it will be possible to extend it to other standards such as UMTS TDD, TD-SCDMA, Edge, DVB-H, DRM, Wi-Fi, WiMAX, CDMA 2000 and IS 136. The hardware will be common for all the standards, only a specific processing DLL will be devoted to each standard.

An obvious improvement allowed with ANTIUM is to realize tests without decreasing the overall quality of the network. Indeed, today, in order to identify the interferers, suspected BTS have to be switched off one by one during the tests. This has a significant impact on the QoS within the concerned cells.

For DVB-T, such a tool will be of high interest when the DVB-T networks will become densified, especially in urban environment where broadcasters will have no other way to identify the origin of DVB-T interference. This densification will probably be effective in a couple of years.

Finally, ANTIUM appears to be a new and efficient tool to help solving interference problem that may appear during the exploitation of a network, but it also appears to be efficient and useful during the deployment and the densification of the network. Thus, using ANTIUM, operators and broadcasters will be able to optimize their network and they will increase the QoS they can provide to the users.

Annex 1

DTV map of the world

There follows maps, which identify the adoption of the different DTV standards around for the world for terrestrial, satellite and cable system.

Figure 1.1 – Adoption of the digital terrestrial television around the world

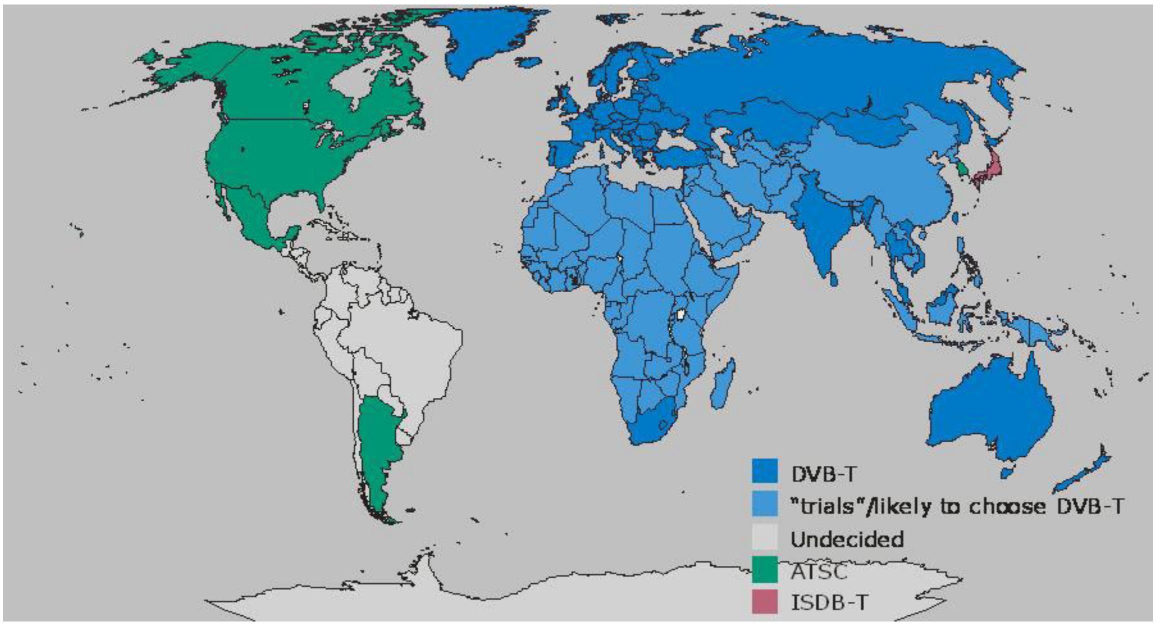
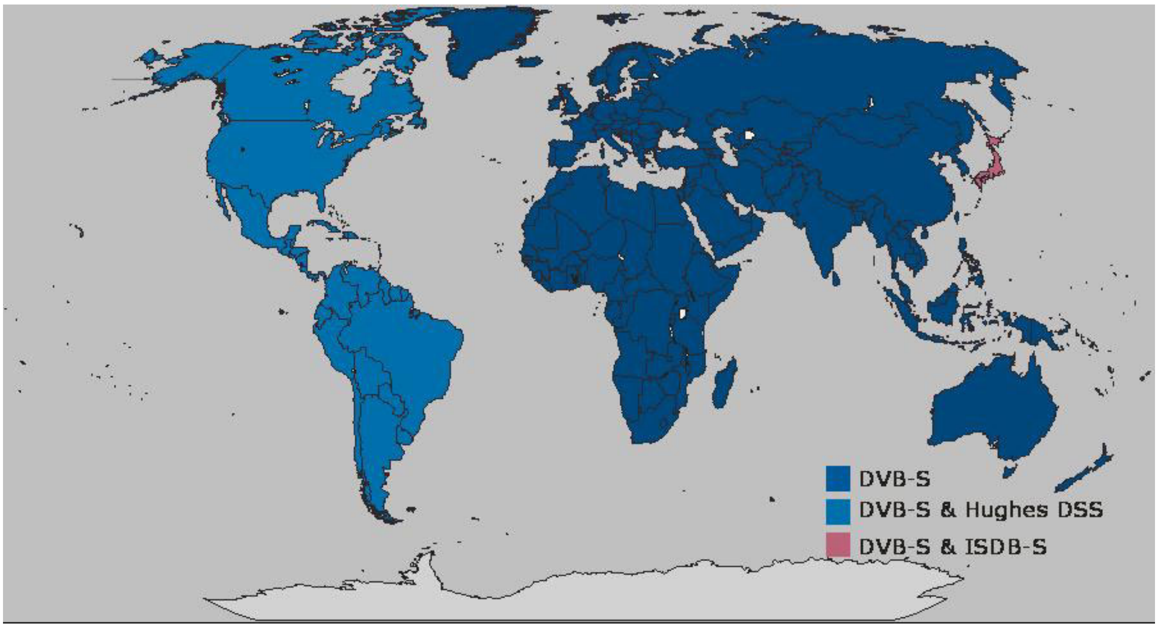


Figure 1.2 – Adoption of the digital satellite television around the world



Annex 2

System choices for satellite, cable and terrestrial digital television systems around the world (July 2004)

DTTB standard. Annex 2 contains a summary of the digital television system choices in selected countries around the world. See also Annex 1 – the DTV world map.

Country or Region	Satellite TV	Cable TV	Terrestrial TV (status)	
European Union (15 states)	DVB-S	DVB-C	DVB-T	Adopted and launched in Sweden, Germany, Finland, UK, Spain, etc.
Arab States	DVB-S	DVB-C	No formal announcement	Recommended DVB-T adoption
Russian Federation	DVB-S	DVB-C	DVB-T	Adopted, trial transmissions
India	DVB-S	DVB-C	DVB-T	Adopted, trial transmissions
Singapore	DVB-S	DVB-C	DVB-T	Adopted, TvMobile services
Australia	DVB-S	DVB-C	DVB-T	Adopted, HDTV services
New Zealand	DVB-S	DVB-C	DVB-T	Adopted, trial transmissions
Malaysia	DVB-S	DVB-C	No formal announcement	DVB-T Industry recommended
Thailand	DVB-S	DVB-C	No formal announcement	DVB-T Industry recommended
Indonesia	DVB-S	DVB-C	No formal announcement	DVB-T Industry recommended
Mexico	DVB-S DirecTV (DVB-S like)	DVB-C OpenCable (DVB-C like)	ATSC	Not yet implemented
Hong Kong	DVB-S	DVB-C	No formal announcement	DVB-T recommended
China	DVB-S	DVB-C	Choosing	Decision will be between DVB-T and a domestic system
Argentina	DVB-S DirecTV (DVB-S like)	DVB-C OpenCable (DVB-C like)	Formally ATSC	Decision for ATSC in 1998, no services planned
Brazil	DVB-S DirecTV (DVB-S like)	DVB-C OpenCable (DVB-C like)	Choosing	DVB-T/ATSC/ISDB-T being considered
Japan	DVB-S ISDB-S (DVB-DSNG like)	DVB-C like	ISDB-T	Implemented

Country or Region	Satellite TV	Cable TV	Terrestrial TV (status)	
Taiwan	DVB-S	DVB-C	DVB-T	Adopted, trial transmissions, after switch from ATSC
USA	DVB-S DirecTV (DVB-S like)	DVB-C OpenCable (DVB-C like)	ATSC	Implemented
Canada	DVB-S DirecTV (DVB-S like)	DVB-C OpenCable (DVB-C like)	ATSC	Not yet implemented
South Korea	DVB-S	OpenCable (DVB-C like)	ATSC	ATSC decision being reviewed
Philippines	DVB-S	DVB-C OpenCable (DVB-C like)	Choosing	DVB-T or ATSC
Rest of Latin America and the Caribbean	DVB-S	DVB-C OpenCable (DVB-C like)	Choosing	DVB-T or ATSC

DVB-T systems have been deployed in a variety of frequency channels (6, 7 and 8 MHz) and business models (HDTV, STDV, free-to-air, pay-TV).

Annex 3

Glossary of abbreviations

AFS	Alternative Frequency Switching
AM	Amplitude Modulation
ARIB	Association of Radio Industries and Business
ATSC	Advanced Television Systems Committee
BER	Bit Error Rate
CELP	Code Excited Linear Prediction
COFDM	Coded Orthogonal Frequency Division Multiplex
CWDM	Coarse Wavelength Division Multiplexing
DAB	Digital Audio Broadcasting
DC	Direct Current
DCP	Distribution and Communications Protocol
DMB-T	Digital Multimedia Broadcasting – Terrestrial
XDSL	x Digital Subscriber Line
DRM	Digital Radio Mondiale
DSB	Double Side-Band
DTT	Digital Terrestrial Television
DVB	Digital Video Broadcasting
DVB-T	Digital Video Broadcasting – Terrestrial
DVB-H	Digital Video Broadcasting – Handheld
DWDM	Dense Wave Division Multiplexing
ETSI	European Telecommunications Standards Institute
FAC	Fast Access Channel
FM	Frequency Modulation
GSM	Global System for Mobile communication
GPRS	General Packet Radio Service
GPS	Global Positioning System
HF	High Frequency
HFC	Hybrid Fibre/Coaxial
HVXC	Harmonic Vector Excitation Coding
IBOC	In Band On Channel
IEC	International Electrotechnical Committee
IP	internet Protocol
IPR	Intellectual Property Rights
IRD	Integrated Receiver and Decoder
ISDB-T	Integrated Services Digital Broadcasting – Terrestrial
ISDN	Integrated Services Digital Network
ITU-R	International Telecommunication Union – Radiocommunication Sector

LAN	Local Area Network
LF	Low Frequency
LMDS	Local Multipoint Distribution System
LW	Long Wave
MCI	Modulator Control Interface
MCS	Multiple Channel Simulcast
MDI	Multiplex Distribution Interface
MER	Modulation Error Ratio
MLC	Multi Level Coding
MF	Medium Frequency
MFN	Multi Frequency Network
MMDS	Multichannel Multipoint Distribution System
MPEG	Moving Picture Experts Group
MSC	Main Service Channel
MW	Medium Wave
NTP	Network Time Protocol
NVIS	Near Vertical Incidence Sky-wave
NVOD	Near Video On Demand
PC	Personal Computer
PFT	Protection, Fragmentation and Transport
PSTN	Public Switching Telephone Network
QAM	Quadrature Amplitude Modulation
QoSAM	Quality of Service in the digitized AM bands
RCT	Return Channel Transmission
RDS	Radio Data System
RF	Radio Frequency
RFP	Radio Frequency Phase
RRB	(ITU) Radio Regulatory Board
RSCI	Receiver Status and Control Interface
RT	Remote Terminal
SBR	Spectral Band Replication
SCE	Service Component Encoder
SCS	Single Channel Simulcast
SDC	Service Description Channel
SDI	Service Distribution Interface
SFN	Single Frequency Network
SNR	Signal to Noise Ratio
SOHO	Small Business or Home Business
STB	Set Top Box
SW	Short Wave

TAG	Tag
UDP	User Datagram Protocol
UMTS	Universal Mobile Telecommunications System
USB	Universal Serial Bus
VOD	Video On Demand
VSAT	Very Small Aperture Terminal
VSB	Vestigial Sideband
WAN	Wide Area Network
WARC	World Administrative Radiocommunication Conference (ITU)
WiMAX	Worldwide Interoperability for Microwave Access
WLL	Wireless Local Loop
WRC	World Radiocommunication Conference (ITU)

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