SEE STRATEGIC ROADMAP TO DIGITALIZATION

Project: South-East European Digital Television

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GLOSSARY

AGCOM - Autorità Garante per le Comunicazioni (Italy)

API - Applications Programme Interface

ASO - Analogue Switch Off

CA - Conditional Access

CBR - Constant Bit Rate

CDN - Content Delivery Network

CI - Common Interface

COFDM - Coded Orthogonal Frequency-Division Multiplexing

CSA - Conseil Supérieur de l'Audiovisuel (France)

DD - Digital Dividend

DTT- Digital Terrestrial Television

DVB – Digital Video Broadcasting

DVB-H - Digital Video Broadcasting Handheld

DVB-T - Digital Video Broadcasting – Terrestrial

ECM - Entitlement control messages

EMM - Entitlement management messages

ERP – Effective Radiated Power

ETSI - European Telecommunications Standards Institute

FDD - Frequency division duplex

FTA - Free to Air

GE06 – Geneva Agreement 2006

GPS - Global positioning system

HBB - Hybrid Broadcast Television

HbbTV - Hybrid Broadcast Broadband TV

HD – High Definition

HEVC - High Efficiency Video Coding

iDTV - Integrated Digital television set

IMC – Independent Media Commission

IRD - Integrated Receiver Decoder

ISI (Inter-Symbol Interference)

ITU – International Telecommunication Union

LCN – Logical Channel Number

MFN – Multi Frequency Network

MHP - Multimedia Home Platform

MHEG-5 - http://www.mheg.org/users/mheg/archives/doc/MHEG-5_Profile_Issue_1.pdf

MPEG - Moving Picture Experts Group

MUX - Multiplex

NMHH - National Media and Telecommunications Authority (Hungary)

OSCE – Organization for Security and Co-operation in Europe

OTT-TV - Over-the-Top TV

QOS - Quality Of Service

PBS: Public Broadcaster Service

PTV - Pay TV

PVR - Personal Video Recorder

RR – ITU Radio Regulations

SAS - *subscriber* authorization system

SC - Smart card

SD – Standard Definition

SFN – Single Frequency Network

SMS - Subscriber Management System

STB - Set Top Box

TDD - Time Division duplex

UHDTV - Ultra High Definition Television

VBR - Variable Bit Rate

1 INTRODUCTION

The report contains several proposals and recommendations for the media digitalization strategy of the SEE area and provides a methodology for transition to the digital system in the different countries. The methodology takes into account the complex correlation between technical, regulatory and socio-economic elements in the broadcasting sector and the different stages of the migration process of each individual country. Furthermore, the report provides implementation strategies and the necessary information on how to promote the migration to digital terrestrial television and to the latest digital transmission, compression technologies and sets indicative deadlines for the switchover process.

2 GENERAL OVERVIEW OF DTT IN THE "digi.TV" COUNTRIES

This document will identify groups of countries with homogeneous state of advancement in the digitalization process:

Country	Cable	Satellite	Terrestrial	IPTV
Albania	-	a.80%	-	-
Austria	a.30% d.10%	a.2% d.49%	d.5%	d.4%
Bosnia and Herzegovina	a+d 24.4%	4.88%	a. 66,29%	d. 4.43%
Croatia	a.+d.9,7%	a.+d.5,6%	d.62,4%	d.22,3%
Hungary	a.42% d.17%	d.23%	a.16% d.2%	-
Italy	d.2,8%	d.33%	a.29% d.35%	d.2,8%
Macedonia	a.54,7% d.5,0%	a.2,0% d.8,2%	a.31,5% d.7,0%	d.4,6%
Montenegro	d.9,1%	d.17,9%	a.39,1%	d.24,0%
Serbia	a+d. 42,13%	d. 8,84%	a. 44,13%	d. 4,9%
Slovenia	a.36% d.5%	d.3%	d.17%	d.39%

Countries such as Croatia and Slovenia have completed the analogue switch off at the end of 2010, Austria has completed the analogue switch off in 2011 whilst Italy is going to complete the analogue switch off in June 2012.

2.1 DTT in Albania:

Albania with a population of 2.8[1] M has about 1M TV households. The country shows a chaotic broadcast environment. Endemic problems include financial opacity, questionable editorial independence, and political control over the media regulator.

Since 15 July 2004, pay-DTT services over 4 Multiplexes have been available from DigitAlb, part of the Topmedia Group which also owns the broadcaster Top Channel. DigitAlb launched DTT services in the western part of the country offering up to 40 pay TV channels. Since then, DigitAlb claims a full national coverage with well over 120,000 subscribers for its satellite and DTT services[2]. In addition, it has offered mobile television services using the DVB-H standard since 2007 till 2010.

However, these DTT services operate outside of the current legal framework for broadcast services which was adopted by the Parliament in May 2007, has no license and therefore operates illegally.

The legal framework allows for the launch of up to seven national DTT multiplexes[3], two of which are reserved for the public service broadcaster. No single service operator can manage more than one national multiplex and at least 50% of its services must be offered free-to-air.

While the date for analogue switch-off has been postponed to 17 June 2015[4], broadcasters must provide the simulcast of their services on the analogue and digital terrestrial platforms until the penetration of DTT services has reached 90% of the population.

While DigitAlb would like to bring its DTT service within a legal framework, the current DTT legislation is unable to authorize its activity given that DigitAlb operates more than one national DTT multiplex and does not offer any free-to-air content. Provisions for DigitAlb to conform to the DTT legislation are unlikely as it would require a reduction in its service offering which would impact its business model and subscriber base. The new law “On audiovisual services in the Republic of Albania” which is expected to be approved very soon, provides the solution of this situation. Upon the draft law: Implementation of DVB-T2 system instead of DVB-T and MPEG -4 compression instead of MPEG-2, will increase the capacity to carry out all existing programs.

There are two other companies operating DTT platforms (TRING, TV SHIJAK) without any license.

The Strategy for conversion to digital broadcasting, approved by the Council of Ministers on May 2012 provides guidelines for implementation of Digital terrestrial networks as follows

-1-2 National Muxes for Public Service Broadcaster;

- 3 National Muxes for national Private Operators

- 11 Local Muxes for Private Local Broadcasters

[1] Last Census data (October 2011)
[2] Digitalb DTT Services cover about 50% of Albanian territory
[3] Due to the freeing the Digital Dividend band, the number of DTT multiplexes is reduced to 5
[4] This date is expected to be approved by the draft law under discussion in the National Assembly

No other companies have shown an interest in entering the DTT market and the public service broadcaster's inadequate funding has not allowed it to launch an alternative DTT platform.

2.2 DTT in Austria:

In the year 2001 the Austrian Communications Authority (KommAustria) was established, with the purpose of leading the regulation of analogue and digital broadcasting.

In 2002 the Austrian Government set up a collective group called "Digital Platform Austria" to ease the digital switch-over process in Austria. It tasked with developing scenarios for the introduction of digital terrestrial broadcasting and supporting future multimedia services.

The Strategic plan for digital switchover "Digitisation strategy for the introduction of digital terrestrial television in Austria" was published in the year 2003. It was developed by KommAustria with the assistance of the "Digital Platform Austria". In line with the specifications of the Austrian Digitization Concept, the regulatory authority had to publish invitations to tender for multiplex platforms and allocates them (along with the relevant frequencies) to the most suitable applicant. In this context, a number of requirements were imposed on the multiplex operator, mainly with regard to the selection of channels. Broadcasters were therefore no longer selected by the authority itself. This task is handled by the multiplex operator according to the procedure and criteria prescribed by the regulatory authority. In cases where these requirements are violated, the authority can intervene upon request or by virtue of office.

The first digital terrestrial television trials were conducted in Austria during the years 2003 and 2004 in the area around Graz.

In 2005, two coverage licenses (MUX A and MUX B) on a single multiplex platform were jointly put out to tender. MUX A supported nationwide coverage with the channels previously broadcasted throughout Austria by terrestrial means (ORF 1, ORF 2 and ATV). The second MUX B platform could be used to broadcast additional channels, which may vary according to region.

In 2005 KommAustria opened its application process for a license to operate the first Austrian multiplex. The successful applicant had to be responsible for all aspects of the digital process from assembling the multiplex, signal distribution and its transmission.

In 2006 the Austrian government awarded the broadcast network operator ORS (Austrian public broadcaster ORF's transmission services subsidiary) a license to launch DTT services in Austria.

Shortly after this decision Austrian DTT services were launched in October 2006. Viewers were able to receive three television program services, ORF1, ORF2 and the National commercial service ATV+ alongside with MHP services. In addition, a second regional version of ORF2 was also made available to the viewers. All these services were operated from MUX A.

A second multiplex (MUX B) was intended to start operation in October 2007 Six channels were announced in Austria's second digital terrestrial multiplex. The multiplex would comprise culture channel 3sat, Sport Plus, etc. . Also this second MUX B is operated by the ORS.

The digital switchover to DVB-T digital terrestrial television was phased over a period of time; the nine regional capitals were switched over to the digital terrestrial signal first, then all the remaining areas followed in stages.

A third multiplex (MUX C), mainly reserved for regional broadcasters, was opened for applications late 2007 and its operations by different local companies started afterwards

At the beginning of 2008 Germany based broadcasting network operator Media Broadcast (formerly T-Systems Media Broadcast) won the tender for a multiplex license (MUX D) to set up an Austrian wide DVB-H network. This network went into operation, but the DVB-H technology was no economic success in Austria. Therefore the license was given back by Media Broadcast.

In the year 2010 he Austrian broadcast network operator Oesterreichische Rundfunksender (ORS) started trials with the new DVB-T2 transmission technology.

Analogue Television in Austria ceased on the 7th June 2011 (ASO) when ORS switched off the last remaining 24 analogue TV transmitter sites in the areas around Mariazell and Mürztal.

The ORS network in Austria, with around 450 transmitter sites, provides country-wide distribution of TV and radio channels and 98 percent of all Austrians can receive digital television on MUX A using a terrestrial aerial. The second digital terrestrial MUX B can be received by 80 percent of all Austrians. In addition to nation wide coverage, ORS also provides a distribution facility for regional TV channels via local transmitter chains using transmission frequencies for MUX C.

In August 2011 the Austrian Media Authority “KommAustria” announced the creation of two additional nationwide DTT multiplexes (MUX D & E). These multiplexes (D and E) will use the DVB-T2 standard. Up to 20 new SD TV programmes can be made available in these multiplexes. Interested parties had to submit their proposals for building a DVB-T2 network by the 15th November 2011.

Multiplex F is actually tendered (May 2012).

The Austrian Broadcast network operator ORS was the only applicant for the license to operate two DVB-T2 multiplexes and will also apply for the actual tendering process for MUX F.

Aside these facts the Austrian National Assembly approved new amendments to the Audiovisual Media Services Act (AMG) on 29 February 2012.

These amendments allow the legal framework regulating the terrestrial television platform to adapt to an all-digital environment. Commercial broadcasters are no longer limited to a maximum number of 2 television program services on the terrestrial platform. Instead, they are limited to one DTT multiplex and no more than one-third of the total number of television program services in a particular region

2.3 DTT in Bosnia and Herzegovina:

Bosnia and Herzegovina have a population of 4.6 M and 1.6M TV Households.

Discussions about switchover in the country have started after omission of the deadline which had been determined by the Strategy. It is decided to postpone switchover date until December 01, 2014.

Bosnia's Ministry of Transport and Communications opened a tender for the procurement of digital microwave links for public broadcasting service between Sarajevo, Banja Luka and Mostar. The tender was open until the 16th January 2012. The successful applicant will have 100days to complete the groundwork.

According to Vlatko Drmic from the Ministry of Transport and Communications, the digital links will be ready by summer 2012, if there are no administrative barriers. He added that the switchover to digital for the three public broadcasters will cost around €25 million.

The Promotional campaign will be held and organized by the Ministry and PBS.

The Communications Regulatory Agency will conduct tender for selection of two operators who will deploy digital broadcast over the whole territory based on allotments and according to the Frequency Plan Geneva 2006. MUX A has been allocated for PBS.

2.4 DTT in Croatia:

Croatia, with a population of over 4.4M, has almost 1.5M TV households.

Its DTT services have been divided among 3 Multiplexes:

- MUX A: which includes PBS (HRT1 and HRT2), commercial TV channels (NOVA and RTL) and My Administration Channel
- MUX B: which includes PBS (HRT3 and HRT4) and commercial TV channels (DOMA and RTL2))
- MUX D: for local, regional and three national coverage thematic channels; music (CMC), sports (SPORTSKA TV), business news(KN)

In 2011 the Croatian regulator HAKOM has published recommendations on the minimum technical requirements for digital terrestrial TV receivers (DVB-T and DVB-T2) in the country. Four receiver categories have been indicated: DVB-T/DVB-T2 for decoding MPEG-2 signals in SD; TV sets with integrated DVB-T/DVB-T2 receivers decoding MPEG-2 signals in SD; DVB-T/DVB-T2 receivers to decode MPEG-4 signals in HD as a stand-alone device (MPEG-4 HD STB) that connects to a TV set; and TV set with DVB-T/DVB-T2 receiver to decode MPEG-4 signals in HD (HD MPEG-4 IDTV).

After tendering procedure in October 2011 HAKOM issued license for two DVB-T2 multiplexes to the national consortium (HP Produkcija, OIV and Croatian Post). Thus Croatia after having completed the transition to digital broadcasting in a record time of 10 months during 2010, started DVB-T2 trials shortly afterwards, in 2011. HP Produkcija, Croatian Post and Croatia’s national transmission company OiV, have signed a 10-year digital TV cooperation agreement. As a result, the consortium will operate two DTT multiplexes (MUX C and MUX E), employing DVB-T2 technology and each eventually, in year 2014, covering at least 94% of the population of the country.

2.5 DTT in Hungary

In 2007 the National Communications Authority (NHH) issued its plans for the allocation of DVB-T licenses for consultation. Eventually licenses could be issued for the operation of 5 national DTT multiplexes.

Spectrum was immediately available for 3 of the multiplexes with space for the remaining 2 multiplexes becoming available after analogue switch-off completion aimed at the end of 2011.

NHH was expected to allocate the DTT licenses in early 2008 with services to follow soon thereafter. The invitation to tender for the DTT licenses was expected by mid-2007, and following the publication of the responses of an ad-hoc consultation. In addition, space on the second multiplex had been reserved for DVB-H services

In 2008 the Hungarian National Telecommunications Authority (NHH) issued a call to tender for five DVB-T and one T-DAB multiplexes for a 12 year period. Two TV licenses (mux A and Mux C) were expected to start broadcasting by the end of 2008 whilst the third multiplex (mux B) would have space allocated for mobile TV services, while the remaining two would be introduced following analogue switch off.

The National Communication Authority in Hungary (NHH) reported that it received two bids for DTT licenses to operate all five DTT multiplexes. The bidders were coming from network operator Antenna Hungária and the Slovakian company, Digital Broadcasting. In July 2008 The National Telecommunications Authority (NHH) awarded the license to operate the DTT platform to Antenna Hungária with the 12-year license covering the eventual provision of 5 TV and 1 radio multiplex which would all become operational after the ASO at the end of 2011. At service launch 3 multiplexes would be available. The license also gave Antenna Hungária the right to operate a DVB-H service on the 3rd multiplex.

Antenna Hungária was granted both licenses for the free and pay DTT platforms in 2008. The free-to-air platform (Mindig TV) was launched on December 1st 2008 followed by the pay DTT platform Mindig Extra (formerly Terra+) in May 2010.

In December 2008, Antenna Hungaria launched the subscription-free digital terrestrial commercial service called MinDig TV and since 25 May 2010, encoded pay-tv service were launched on the pay-platform MinDig TV Extra, as well. The services are coded in MPEG-4, H.264 AVC and require an HD compatible DVB-T STB or receiver to view all the transmissions.

Within the frames of MinDig TV service, currently the programs of 7 television channels (m1 HD, m2 HD, Duna HD, Duna World, RTL Klub, TV2, and the program of Euronews in English, German and French) and 4 radio channels (MR1-Kossuth, MR2-Petőfi, MR3-Bartók and NeoFM) are available free of charge.

Since 25 May 2010 the Pay-TV platform uses DVB-T and programs are coded using the MPEG-4. These are: National Geographic, AXN, Film+, Cool, SportKlub, Disney Channel, FEM3, Hír TV, ATV and Private Spice.

Reception of the MinDig TV and MinDig TV Extra services need broadband roof antennas enabling reception of the UHF frequency band and channels 21-69 along with a DVB-T MPEG-4 decoder (set-top-box) or an integrated television set with built-in DVB-T MPEG-4 tuner. So as to receive the MinDig TV Extra pay-tv service, with the appropriate technical settings, a DVB-T MPEG-4 set-top-box handling a Conax-card or - in case of an integrated television set equipped with a DVB-T MPEG-4 tuner - a CA-module are needed.

2010 saw wide-reaching changes in Hungarian media law. A new media Act passed in August 2010 establishing a new converged regulatory authority the Nemzeti Média- és Hírközlési Hatóság - NMHH (National Media and Communications Authority) merging the former telecom regulator, the National Communications Authority - NHH) and the National Radio and Television Commission (ORTT).

In 2011 Antenna Hungaria launched its third DVB-T multiplex with 13 new channels. Since October 2011, the offer of MinDig TV Extra service was expended by more 13 channels as follows: Viasat 3, Comedy Central, Universal Channel, Spektrum, History, Sport 1, Sport 2, Minimax, Cartoon Network, PRO4, Prizma TV, Muzsika TV and Dorcel TV. This way, beside the basic package, a family package (containing 23 pay-tv channels) is available for the viewer, as well. Together with the free-to-air channels a total of 31 programs are currently available on the digital terrestrial television platform.

By the end of 2011, according to Antenna Hungaria DTT coverage reached 98% of the population following the launch of a further 20 transmission sites.

At the beginning of 2012 the DTT platform operator Antenna Hungaria had announced that 300,000 households use the free-to-air DTT platform MinDig TV, while nearly 60,000 households subscribe to the pay-DTT platform MinDig TV Extra.

2.6 DTT in Italy

The committee for the development of digital terrestrial, created by AGCOM, published a white book on DTT (**1999**) which outlined two different paths towards DTT:

- The implementation of the analogue plan and therefore the start-up of DTT over the 4 frequencies reserved for that purpose.
- A totally innovative approach: allowing the trading of frequencies between broadcasters in order to allow the broadcasters interested in launching DTT services to get extra capacity.

In 2001 Law n. 66 paved the path for the introduction of digital terrestrial television by defining:

- trading of frequencies between broadcasters in order to allow the broadcasters interested in launching DTT services to get extra capacity;
- different authorization titeles for: content providers, service providers, and network providers.
- switch-off date;

The Italian regulatory authority (AGCOM) published in 2001 Decision No. 435/01/CONS which defined the the regulatory framework for the start-up of DTT in Italy.

The year **2003** marked a turning point for terrestrial digital television, which entered a new phase of programme trialling and creation of the first nation-wide broadcasts and networks.

It was the year Mediaset, RAI, and Telecom Italia Media began trialling the transmission of programmes and interactive services. At the same time, multiplexes – each with a potential of 4 or 5 television channels – were developed, and 15 digital channels made available.

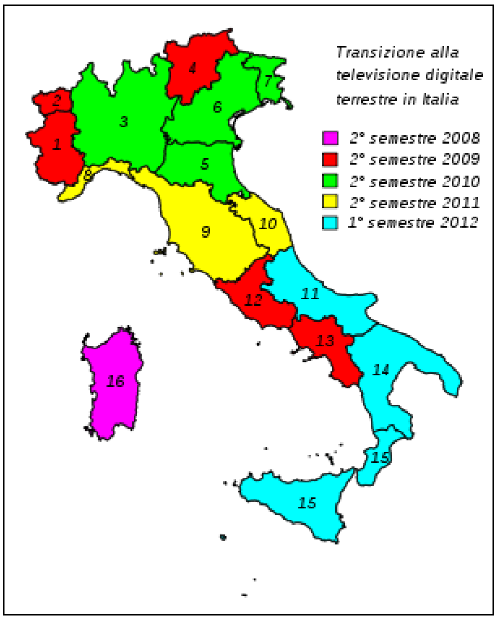
To acquire the necessary frequencies, the companies interested in developing new networks have also seen to purchasing a number of local television broadcasters and the rights to use their frequencies. A major "purchasing campaign" of lesser broadcasters thus took place during 2003 and the early months of **2004**.

Particularly active were Mediaset and RAI, followed by Telecom Italia and HollandItalia, which in collaboration with TF1 – France's leading television operator – purchased the terrestrial frequencies previously used by Tele+. Competition on this front drove up prices for frequencies, which in some cases rose as high as € 1 per person residing in the coverage area.

In **2005** the main novelty for end users was the launch – via the digital terrestrial platform – of pay-per-view offers using the DVB-T (Digital Video Broadcasting -Terrestrial) standard. This service was based on a commercial offer which, by purchasing a prepaid card, allowing the viewer to access different contents, upon the payment of each event. Mediaset and Telecom Italia Media were the operators currently offering this service on the market. They market their products with "Mediaset Premium" and "La 7 Cartapiù" respectively. As to the quality, these contents fall into the category of the so-called premium rights consisting of the offer of movies and sports events.

At the end of **2008**, the number of households having at least one digital terrestrial receiver reached 7.6 million units, equal to 34% of the total of TV households. In 2008, the penetration of digital platforms (53%) outstripped the analogue one (47%), even if with reference to first accesses only, namely to the main TV set in each house. With regard to receivers, in Italy, in December 2008 only, 677,000 TV-sets with integrated STB and 207.000 external set-top boxes were sold, bringing to 12.2 million the total number of units for DDT reception sold so far, of which over 5 million during 2008 only.

In 2007, Law 29 novembre 2007 n. 222 set at the end of 2012 the final switch-off date and defined a "phased approach" based on a gradual transition of "digital island". The transition plan is summarized in the following figure:



Italy's transition plan

The region of Sardinia, (the first Italian territory where transition to digital was completed - October 2008) prior to the switch-off, had 16 local TV broadcasters. Following the transition to the new transmission technique, in Sardinia there counted 18 multiplexes of local operators, for total of 64 TV programmes and 5 radio channels. In summary, the switch off increased significantly national and local programmes that TV viewers can receive as well as pluralism and competition in the sector.

In 2010 AGCOM resolution n. 300/10/CONS defined the Italian frequency plan for DTT by selecting SFN for the 25 national multiplex.

The "phased approach" in the migration to DTT undertaken in Italy, that saw major periods of conversion to digital carried out region by region in **2009** and **2010** led to a 78% coverage of the population by the end of **2011**.

At the end of 2011 the DTT penetration in the Italian households was about 87%, the number of DTT receivers sold in Italy since 2004 had reached 55 millions units and the audience of the DTT platform had reached almost 70%.

September 2011 has seen the closing of the bid for the granting of the "external" Digital Dividend (800 MHz band) to TLC operators. Income has been close to €4 billion.

The beauty contest for the attribution of the "internal" Digital Dividend has been actually stopped. The Minister for Economic Development, has confirmed that the licenses for 6 DTT multiplexes will be allocated using an auction. The decision by the previous government to allocate the licenses via a "beauty contest" has been annulled.

June 2012 shall see the completion of the transition to DTT with the switch off in the remaining 6 regions.

In April 2012 the Italian government has decided that all DTT tuners sold in Italy from 2015 onwards must include the DVB-T2 standard, both for stand-alone set tops and for IDTVs. For consumers, there will be a need to buy new tuners, although a number of DVB-T channels will remain on air for some time.

2.7 DTT in Macedonia:

Macedonia has a population of 2M and 600.000 TV households. The country DTT strategy is to implement 4 Multiplexes.

In 2009 at the opening bids for a license to operate DVB-T services in Macedonia, Telecom Slovenije was the only bidder. On.Net, a subsidiary of Telekom Slovenije plans to transmit up to 60 channels, two of which will be HD.

The same year Telekom Slovenije, through its subsidiary One, launched the pay DTT platform Boom TV. Boom TV in the period between January and June 2011, increased its subscriber base e by 53%.

Telekom Slovenije also acquired Macedonian telecommunications operator Cosmofon that had proposes Boom TV as part of a triple play offer.

In December 2011 a public Company Macedonian Broadcasting launched DTT with 4 programs in Skopje area. ASO is planned for 1 June 2013 (info as per the Agency for Electronic communications announcing public call for operators of 4G networks).

Digital roll-out plan of the public service in Macedonia is facilitated by the PE Macedonian Broadcasting. Government of the country financially supported implementation of the plan by 17M EUR from within 10M EUR aiming digitalization of the services provided by Public Enterprise “Macedonian Broadcasting” and 7M EUR aiming digitalization of Public Broadcasting Service “ Macedonian Radio Television”.

PE “Macedonian Broadcasting” announced certain measures of subsidy targeting approximately 40.000 socially vulnerable households for the first half of 2013.

2.8 DTT in Montenegro:

Montenegro has a population of less than 0.7M and approximately 195,000 TV households. The country DTT strategy was adopted in 2008 but the target DSO date (end of 2012) will not be met due to the significant delay in the infrastructure deployment. Digital Broadcasting Law was adopted in July 2011 (Official Gazette no.34/11) and set the 31 December 2012 as the ASO date.

The procurement of digital transmission equipment for the first MUX was planned to be ensured with the EU support through the IPA funded project "Support to the Digitalisation of the Montenegrin

Public Broadcasting". The main beneficiary of the project is the public operator – Radio-difuzni Centar D.O.O. (hereinafter RDC). The Project has been aimed to assist digital switchover of the RTCG (national PSB) by providing equipment and training to RDC, as the main beneficiary who is the designated first MUX operator according to the Digital Broadcasting Law.

For this purpose, the overall project cost of 2,695,000 EUR has been envisaged, with EU contribution of 1,600,000 EUR. This means 1,095,000 EUR shall be co-financed by state of Montenegro.

The project should be implemented through the three activities including: training sessions, to improve the implementing staff competence for functioning and maintenance of the equipment and systems and the main part of project as procurement of digital transmission equipment for first multiplex (transmitters, gap fillers, TV duplexers, IP to ASI Adapters, MPEG TS multiplexer, MPEG-4 encoders and antennae parts), to be executed in two phases, through the supply contracts, for one phase financed by Montenegro and for another phase financed by Delegation of the European Union to Montenegro.

The contract for the procurement of the EU funded phase was awarded to Italian company Eurotel. Nevertheless it has been delayed and the planned supply, delivery and installation of the Contract defined goods will be postponed for at least half a year, thus definitely making it impossible to start the simulcast as set by the Law on the 1 July 2012.

Since the ASO process has not started yet as planed for 1 July 2012, all activities are postponed until final execution of supply project and final procurement of equipment for the first multiplex. With that regard, the Law was amended in June 2012 in order to postpone the target date not later than 15 June 2015. The amended Digital Broadcasting Law stipulates that simulcast period should last not more than six months after the start of first multiplex network.

2.9 DTT in Serbia:

Serbia has a population of over 8M and has 3M TV households. Trial broadcasting of Digital Terrestrial TV signals in Serbia started in Fall 2011. Because of this late start and because of elections, ASO planned for the 4th April 2012 will be postponed. Two multiplexes are planned for Serbia. Mux 1 will have nationwide programme coverage (95%) as well as some regional programming and Mux 2 will be used for local programmes.

Press announcements state that the DTT platform should launch on March 2012. The network will provide coverage to 40% of the population. It will consist of 13 transmission sites as well as two additional sites in Belgrade as part of its SFN network. Further sites will be launched following the completion of analogue switch-off. The DTT platform will use the DVB-T2 and MPEG-4 AVC standards. A total of 11 television programme services should be available, including some content in HD from the public service broadcaster RTS (RTS1, RTS2, RTS Digital, PINK, B92, PRVA, AVALA, RTV1, RTV 2, Studio B and one regional TV station Belle Amie).

2.10 DTT in Slovenia:

Slovenia has a population of about 2M and 740.000 TV households and its TV service have been allocated to 2 National Multiplexes:

- MUX A: operated by PBS RTV Slovenija
- MUX B: licence held by Norwegian company Norkring should contain 6/8 channels, but is in fact empty as all national channels are on MUX A. According to the EU the MUX A should not contain commercial broadcaster services.

In 2007 Slovenia's National Assembly had approved the countries Digital Broadcasting Act, setting a deadline of 2010 for the completion of the digital switchover process. Slovenia will be covered by eight multiplexes, four of which will be used for digital TV broadcasting. Multiplex operators will be chosen by a public tendering process. One network, reserved for public broadcaster RTV SLO, is already in the build process. APEK announced the selection of the MPEG-4 AVC video compression standard for the DTT platform. The MPEG-4 AVC standard was selected because of its improved spectrum efficiency compared with MPEG-2 and the consequent ability to fit more channels into the available frequency allocations.

Slovenia completed its switch to DTT on the 1st December 2010 with the termination of all analogue transmissions on a single day and has introduced a "green label" to receivers compliant with technical requirements (DVB-T, not yet DVB-T2)

Slovenia has started testing DVB-T2, the second-generation digital terrestrial broadcasting system, in early 2012, reports local news agency STA. The goal of the tests is to establish whether this would improve coverage in areas that are not of interest for commercial providers of broadcasting platforms.

OTHER EXAMPLES:

2.11 DTT in France

August 1st **2000** saw the publishing by French Authority CSA of the criteria for the selection of the channels for DTT. All channels already broadcasting in analogue before that date automatically received authorization to broadcast in digital: public channels France 2, France 3, France 5, Arte; and private channels TF1, M6, Canal+ (pay)

In October **2002** the CSA had selected through a comparative procedure, the 23 national TV channels that went into shaping the DTT lineup.

5 new content providers (AB, Bolloré, Lagardère, NRJ, Pathé) had access to the new platform, that side by side with the historical national TV channels formed the following offer:

- 16 FTA national channels

- 15 national PAY TV channels

The CSA had also established the allotment of the channels into 6 MUX, 2 of which exclusively dedicated to the PSB.

At the same time French Authority introduced the obligations of keeping separate the activities of content providers and MUX operator. For this matter, content providers of the same MUX have joined in Consortiums which have subsequently submitted to the CSA the request for the authorization of operating the MUX.

The following Operators have received authorization to operate the 4 non-public MUX:

- Nouvelles télévisions numériques
- Compagnie du numérique hertzien
- Société opératrice du multiplex R4
- SMR6

In January **2004**, following a decision by the French Government not to launch 2 out of the 8 public TV channels planned, the CSA had chosen to group all PSB channels in the same MUX and open a new comparative procedure to allocate the exceeding capacity.

A new comparative procedure had to be opened in October 2004, as the State Council, after the request by TF1, has annulled 6 out of the 23 DTT broadcast authorizations released to MCM, Canal J, Sport+, I-Télévision, Ciné-Cinéma Câble and Planète Câble.

In 2005 the Ministry of Economy announced that the MPEG-4 (H.264) compression standard must be used for HDTV services on any terrestrial channel both pay and public. MPEG-4 is already obligatory for Pay TV operators whilst public service operators can continue to use MPEG-2 for standard definition digital terrestrial services.

In July **2005** the CSA has issued 8 (6 + 2 new ones) authorizations for 4 FTA channels (BFM TV, I-Télé, Europe 2 TV and Jeunesse TV), and 4 pay TV channels (Canal J, Canal+ Cinéma, Canal+ Sport and Planète).

A further decision has reorganized the MUX lineup: all FTA channels on MUX 2 and all PAY TV channels on MUX 3. This more homogeneous organization of the MUX will enhance efficiency of statistical multiplexing in an environment with a double coding system (MPEG-2 and MPEG-4).

In October 2009 coverage reached 35% of the population and raised to 65% beginning 2011. Total population coverage at switch off is 97,3%.

At the end of 2010, 9 out of 10 French homes (24 million) had at least one digital decoder (satellite, DSL box, DTT or cable box) according to GfK and Mediametrie. DTT receivers are now in 23 million households (84.5%) of which 16.6 million have iDTV’s and 10.8 million have DTT set top boxes

In September 2011 the French regulator CSA, has proposed the immediate adoption of the DVB-T2 and MPEG-4 standards for all new DTT channels. DVB-T2 will allow broadcasters to air four or more HD channels over a single multiplex and together with MPEG-4 will favor the development of HD, which is expected to be supported by 95% of French TV sets by 2015.

France switch off was completed in November 2011. This brings an end to SECAM transmissions. The ASO process began in October 2009 and in 2010 had covered 35% of the French population in 10 regions. By 2011, 14 regions covering 65% of the population had achieved ASO. Coverage has now reached 97.3% of the population and those unable to receive terrestrial TV can view the free-to-air channels via satellite using a subscription-free smart card.

The increase in the number of free TV channels in respect to the previous analogue offer seems to have given impulse to the fast adoption of the new platform by the population. In fact these new channels register excellent progress in terms of share going from 19.7% in 2010 to 23.1% in 2011.

On the other hand the pay DTT offer is having difficulties meeting its targets and operators such as C-Foot and TPS have chosen to withdraw from the platform. To help the process of adoption of DTT it has been fundamental the contribution of the rebroadcasting of the DTT lineup on FTA satellite. TNT and Fransat have registered 3.3M DTH receivers sold as of December 2011.

The assignation of the digital dividend which is destined to mobile broadband services took up in 2011. License to the use of 800 MHz band has been granted to Bouygues Telecom, Orange and SFR. Total income (800 MHz and 2,6 GHz bands) has been €3,5 billion.

In October 2011 the Conseil supérieur de l'audiovisuel (CSA) had launched a call for applications for six HD channels to broadcast on the French DTT system. The channels will broadcast in DVB-T/MPEG-4 over the R7 and R8 multiplexes. The deadline for applications was the 3rd January 2012 with the candidates selected in mid-March. The formal licensing process will be completed at the end of May 2012. The second half of 2012 should hence see the launch of 6 new HD channels for which French Authority CSA has already announced a beauty contest. Licenses should be awarded in May 2012. After that the HD offer will encompass 11 TV channels.

In 2012 it is foreseen an acceleration of the development of "hybrid" OTT-TV offers (Over-the-Top TV), for which the most important broadcasters have already started testing with interactive services delivered via the Internet on connected TV sets with HbbTV technology.

2.12 DTT in the U.K.

In **1997** the British Government announced for the first time the introduction of DTT.

The platform was organized into 6 MUX (multiplexes: 1,2,A,B,C,D). MUX 1 was destined to PSB BBC. An Independent Television Commission (ITC) was created to allocate the other 5 MUX.

ITC gave each national broadcaster 50% of a MUX: ITV and Channel 4 shared MUX 2; Five and SC4 shared MUX A; the remaining B, C, D were available for a comparative procedure (Beauty Contest).

Founding criteria of the Beauty Contest:

- Guiding principles: Digital terrestrial television is licensed under a two-tier structure whereby the carriage and delivery system, the multiplex, is licensed separately from the program and additional services which are carried on the multiplexes
- Selection criteria: The ITC must judge how well multiplex license applicants would promote the development of DTT broadcasting based on a number of criteria, i.e. coverage proposed; speed of the roll-out of the service; ability to establish and maintain the service; the appeal of the program services to a variety of tastes and interests; plans for promoting or assisting the acquisition of decoders by viewers; and plans to ensure fair and effective competition in their dealings with providers of program and additional services. A points system is used for ownership matters. Applicants do not submit cash bids.
- License Conditions: Digital multiplex licenses are awarded for a 12-year (renewable) license term. Compared with satellite/cable, there are tougher positive requirements regarding variety, original productions/commissions, first-run programs, European Programs, independent productions, training and equal opportunities, subtitling, sign language and audio description. There is also a requirement for interoperability.

In June **1997** ITC released license to multiplexes B,C e D to British Digital Broadcasting (BDB, later named ONdigital, and today called ITVdigital). The only other applicant was a consortium associating Granada, Carlton and BskyB. The latter company was forced out by the ITC, because its presence in the consortium would have increased its vertically and horizontally dominant position on the British pay TV market.

In **2002** ITV Digital went bankrupt and the Freeview consortium, (formed by the BBC, transmitter company National Grid Wireless, known at the time as Crown Castle UK and BSkyB) was created to participate to the bid for the freed up MUX B, C and D. This consortium (legal name DTV Services Ltd and trading under the "Freeview" brand) won and launched a new service. Dropping the ITV Digital failed business model, Freeview launched on 30 October 2002 with free television channels only.

In **2003** British Government publishes the "Communications Act 2003"[5] that defines obligations that Authority Ofcom needs to implement in the audiovisual and TLC markets.

Among these conditions, Ofcom imposes EPG (Electronic Program Guide) providers to respect principles of non-discrimination in the creation of channel line-ups, with particular attention to PSB channels.

Guidelines for the creation of EPGs indicated by Ofcom are:

[5] http://www.legislation.gov.uk/ukpga/2003/21/contents

- Objective principles for the creation of the ranking of channels that avoids giving priority to channels linked to the EPG provider.
- Guarantee that viewers can access all services and channels available in the area.
- Guarantee that both PAY and FTA services be available
- Making sure that FTA channels and PAY TV can be accessed through the same receiver
- Interdiction of exclusive agreements with content providers.

In May **2004** Top Up TV was launched to provide subscription content in hitherto unused space on multiplex 2 rented by Top Up TV from Channel 4 and on multiplex A, rented from Five.

In October **2005** ITV plc (Public Limited Company founded in 2004) and Channel 4 joined the Freeview.

In October **2006**, Five launched two new free-to-air digital channels.

In November 2006, the DTT pay content provider launched Top Up TV Anytime, a service which broadcasts overnight "downloads" which are recorded by a proprietary personal video recorder (PVR).

Hereafter how the different MUX are being operated and their names today:

Old multiplex name	New multiplex name	Owning company
1	BBC A	BBC
2	D3&4	Digital 3&4
A	SDN	S4C Digital Networks (ITV plc)
B	BBC B	BBC
C	Arqiva A	Arqiva
D	Arqiva B	Arqiva

Currently, 3 MUX (multiplexes 1, 2 and B) will be for public service broadcasting and contain around 25 TV channels, including all the television channels from the BBC, ITV (except ITV2+1), Channel 4 (except Film4 and E4+1), S4C and Channel 5 (except 5 USA and 5*), half a dozen radio stations and half a dozen text/interactive services. The other three multiplexes (A, C and D) will continue to be operated by their respective commercial licence-holders.

In 2010 mux B migrated to DVB-T2 standard MPEG-4 encoding. This multiplex is controlled by the service company Freeview HD, which has offered to host up to five DVB-T2 HD channels on it. Freeview HD started its "technical launch" on December 2, 2009, hosting BBC HD, and ITV1 HD. In 2010 Freeview HD had its official launch, and added Channel 4 HD whilst the fourth channel hosted is BBC One HD. The remaining fifth slot is still to be assigned.mux B BBC HD, BBC One HD, ITV1 HD and 4HD

The past year has been crucial in the transition process to DTT, although still a lot remains to be accomplished. Beginning 2011 the switch-off had concerned short less than 40% of the population, but reached 65% at year end (11 out of 15 regions became all digital).

During 2011 the linear free DTT offer has gained new significant TV channels, but most importantly the first "hybrid" broadcast/broadband (both linear and non linear such as VOD) services have been launched. In the meantime the share of the new DTT TV channels show a further increase widening their audience from 22.1% of 2010 to 23.6% of 2011.

Digital UK has announced at the end of 2011 that the end of analogue TV in the UK will finally come on the 24th October 2012, Northern Ireland will be the final region to complete analogue switch-off in the UK and will do so on the same day as the completion of the ASO in Southern Ireland. In London this will happen in early April, only a few months before the Olympic Games. During 2012 a further 35% of the population will migrate to DTT. In the meantime, before the end of the year, the Bid for the assignment of the Digital Dividend to the TLC operators should be completed. The ASO process in the UK began in 2008 using DVB-T and has progressed on a region by region basis.

2012 will see the enrichment of the DTT offer in many ways: HD channels will be available to all households; OTT TV will see further expansion; and on the other hand we may see the launch of the first local/regional channels, subsequent to a plan by the U.K. Government to create a network of regional TV channels, never before developed in the U.K.

In 2011 Ofcom has opened a consultation on proposals for the allocation of spectrum in the 800 MHz and 2.6 GHz band. These frequencies will be used to deliver future 4G services such as WIMAX and LTE as well as other broadband services. Ofcom plans to publish the license regulations in the autumn and begin the auctions in the first quarter of 2012.

2.13 CONCLUSION:

The above focus on the advancement of the digitalization process on the different SEE countries is functional to the methodology we apply in this paper to provide accurate recommendations for each country.

We can note that there are different stages in the introduction of technologies reached in each region. Countries have therefore been classified into three groups or clusters according to the achievement and progress in the transition towards DTT:

- **Group A**: a first cluster includes the countries where DTT has been successfully launched, ASO is imminent or has already been achieved and, where the regulation and policies provide a healthy environment that allows development of commercial activities.
  - Croatia
  - Slovenia
  - Austria
  - Italy
  - Hungary
- **Group B**: a second cluster includes the countries where DTT services have already been initiated and commercial activities have been launched
  - Albania
  - Macedonia
- **Group C**: a third cluster consists of countries where a regulatory framework for the launch of DTT has not yet been completed and the transition to DTT is still at an early stage.
  - Serbia
  - Bosnia and Herzegovina
  - Montenegro

3 OBJECTIVES, STRATEGIES AND ROADMAP FOR SEE

The terrestrial network should be given the tools to enable it to offer the development of new services and technologies that consumers demand and which is available on other distribution platforms.

The final goal of the digitalization process is not only to reach the analogue switch off in all the SEE Countries but also to have an integrated system of technologies that efficiently uses the broadcast spectrum and thus enables the introduction of new mobile and broadband services.

3.1 Technology Drivers

The EU Commission published a consultation document in July 2009 about the digital dividend, where issues were discussed for a common plan in order to develop DTT (European Commission. Information Society and Media Directorate-General, *Transforming the digital dividend opportunity into social benefits and economic growth in Europe*, 2009). The document shows the importance of increasing consumer experiences by securing high quality standards for terrestrial television receivers in Europe.

The document also states that consumers have high expectations on future development of television broadcasts when it comes to more television services and improved quality, for example HD TV. Coordinating European broadcasting can, according to the Commission, facilitate the switch to more effective and versatile broadcasting systems. In particular, there is an evident momentum behind HDTV fuelled by large flat panel HD and HD-ready screens, the availability of HDTV on other platforms, most notably satellite, and the transition to HD in recorded media and games consoles. It is likely that consumers' expectations will change over time to see HD as the norm. Unless DTT becomes HD, consumers are likely to abandon it in favor of satellite or cable. This is why at least if countries do not want that their terrestrial network be used only for poor reception of television there is the need to plan the introduction of such enhanced broadcast services as HDTV.

It is also worthwhile to mention that other television format as 3DTV and UDTV are showing high success. The DVB-3DTV Committee has already issued specifications for the Compatible Frame transmission systems for eight different formats (including 720p/50 or 60, or 60 1080i/50 and 1080p/24) interfacing via HDMI connection and the criteria to be adopted to allow proper viewing of stereoscopic image graphics and subtitles. These specifications are used in 3D TV broadcasts already in service by many broadcasters and 3D TVs on the market.

The second stage will define the standard for Service Compatible systems and is expected in late Summer 2012.

3D TV is also developing from the commercial point of view. In fact several satellite pay-tv broadcasters (Canal+, SKY, SKY ITALIA, etc.) have also launched their 3D TV broadcast services and more recently 3D TV contents have been broadcast also on DTT. 3D TV sets penetration is also showing rapid penetration.

Lastly, it is to mention that the International Telecommunication Union (ITU) has recently (end of 2011) revealed new technical specifications for Ultra High Definition Television (UHDTV) and test trials are in course worldwide. Also UHDTV needs high bandwidth because of the increased screen resolution to around 33 million pixels (7690 by 4320) which is about 16 times the resolution of current HDTV

3.1.1 MPEG4 (H.264/MPEG-4)

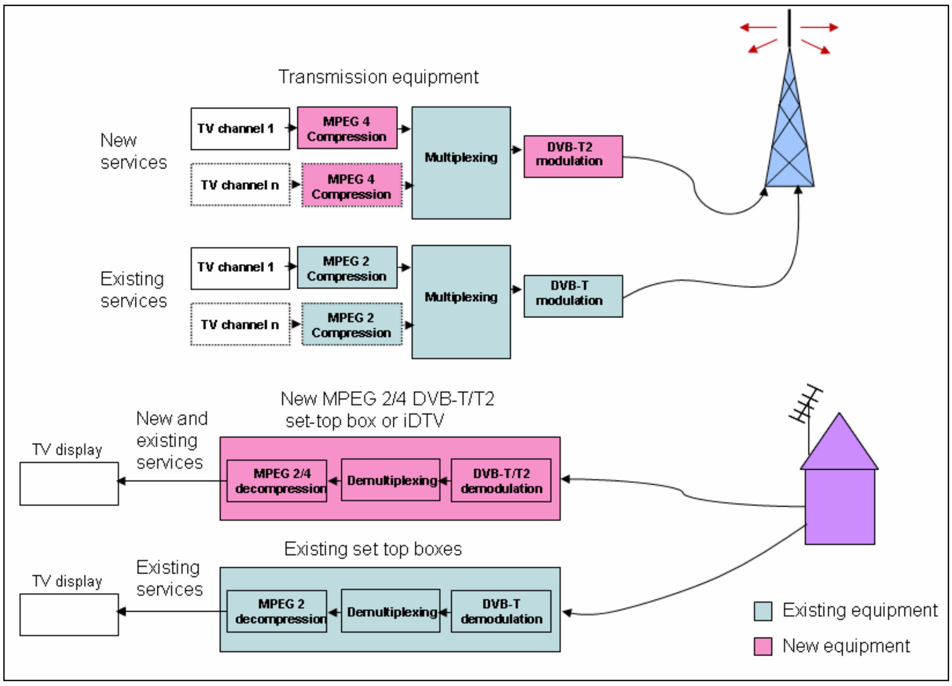
MPEG-4: this is an improved video and audio coding compression standard the use of which will result in more efficient compression of video and audio services. H.264/MPEG-4 Advanced Video Coding standard (H.264/AVC for brevity), which is also known as H.264/MPEG-4 Part 10. H.264/AVC in turn compresses video significantly more efficiently than MPEG-4 The compression algorithm used in MPEG-4 AVC/H.264 is basically the same as that used in MPEG-2. To understand the complexity of the new compression standard, compared to MPEG-2, MPEG-4 AVC (H.264) requires 8 times the processing power for encoding and 3 times the processing power for decoding. So developing encoder and decoder technology is not trivial, especially if performance is a concern.

It is projected that, over time, services coded using MPEG-4 AVC/H.264 will be able to operate at up to a maximum of twice the efficiency of those using the current MPEG-2 standard. This means that, in principle, a multiplex could carry up to a maximum twice as many services using MPEG-4 as can currently be achieved using MPEG-2 whilst maintaining a similar picture quality. The following table shows the number of services that a mux can typically carry when using MPEG-2 and H.264/MPEG-4:

	Mpeg-2 Dvb-T	H.264/MPEG-4 Dvb-T
SD	4-6	8 - 12
HD	1-2	3-5

MPEG-4 is based upon the existing MPEG-2 standard but includes some additional tools which mean that services coded using MPEG-4 are not backwards compatible with existing MPEG-2 receivers. As a consequence viewers will have to purchase new consumer reception equipment (set top boxes (STBs) or integrated digital televisions (iDTVs)) for reception of services using MPEG-4. The new MPEG-4-compliant receivers, which are generally also DVB-T2 compliant, are normally backwards compatible with existing MPEG-2/DVB-T standards and hence they will pick up all free to air services on DTT.

The diagram below shows where in the TV production chain new equipment would be required as a result of an upgrade to MPEG-4 (and DVB-T2), for the transmission and reception of new services:



System changes needed to deliver MPEG-4 and DVB-T2 services
Source: Digital Television: OFCOM - Enabling New Services Facilitating efficiency on DTT

The figure shows also that from the receiver side and that from the transmission side only the encoders will have to be changed going from MPEG-2 to MPEG-4. Furthermore, it is possible to mix MPEG-4 and MPEG-2 coded services on a single multiplex.

The next table provides information regarding the costs needed to buy MPEG equipment:

	MPEG-2	**MPEG-4**
Encoder	7.000 – 9.000 Euro	10.000 – 12.000 Euro

According to the table, the price of MPEG-4 equipment is not significantly higher than MPEG-2, presenting the financial aspect of DVB-T2/MPEG-4 as an advantage.

MPEG-4 is used on the satellite and cable platforms in the UK and is increasingly being used on DTT internationally.

3.1.2 DVB-T2

Effective use of the available spectrum will be achieved not only by a more effective compression technology like MPEG4, but also by introducing a new transmission standard.

DVB-T2 is innovative since it is the improvement and upgrading of the existing standard DVB-T. In 2008 the DVB committee presented DVB-T2 specification to ETSI (European Telecommunications

Standards Institute) which gave the final approval of DVB-T2 in September 7, 2009 (ETSI EN 302 755 V1.1.1 (2009-09).

The new features of DVB-T2 provide greater efficiency to the performance of the digital terrestrial platform, compared to the first-generation systems (DVB-T), which allows an increase spectral efficiency, or more bits / s / Hz. In other words, for the same band, more television channels can be transmitted or the same number of television channels, but in higher quality (for the same transmission parameters of all the increment in terms of bit rate and therefore the number of channels is equal to about 35/40%).

As a result, DVB-T2 can offer a much higher data rate than DVB-T or a much more robust signal. For comparison, the following table show the maximum data rate at a fixed C/N ratio and the required C/N ratio at a fixed (useful) data rate:

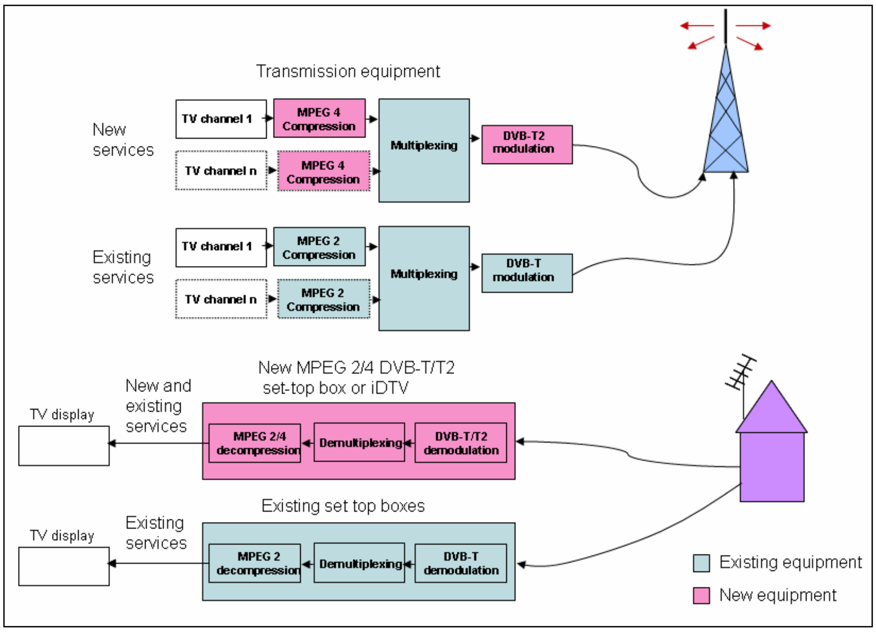
	DVB-T	DVB-T2
Typical data rate (UK)	24 Mbit/s	**40.0 Mbit/s**
Max. data rate (@20 dB C/N)	29 Mbit/s	**47.8 Mbit/s**
Required C/N ratio (@22 Mbit/s)	16.7 dB	**8.9 dB**

The following table shows the number of services that a mux can carry when using MPEG-2 and H.264/MPEG-4:

	Mpeg-2 Dvb-T	H.264/MPEG -4 Dvb-T	H.264/MPEG-4 DVB-T2
SD	5-7	8-12	10-16
HD	1-2	4-5	5-6

Such efficiency (DVB-T to DVB-T2) is even larger when a statistical multiple is used because gains can be typically expected to asymptotically approach a value between about 25 and 30% for large numbers of channels.

The diagram below shows where in the TV production chain new equipment would be required as a result of an upgrade to DVB-T2 (and MPEG-4) , for the transmission and reception of new services:



System changes needed to deliver MPEG-4 and DVB-T2 services
Source: Digital Television: OFCOM - Enabling New Services Facilitating efficiency on DTT

The figure shows also that from the receiver side

From the transmission side the modulator and the Mux will have to be changed going from DVB-T to DVB-T2. Hence, in order to adopt DVB-T2 a complete multiplex would have to be converted.

For DVB-T2 the existing infrastructure (from analogue TV or DVB-T) which is related to antennas, masts, amplifiers, repeaters (although not re-transmitters which re-generate the signal), etc. at the transmitting side can be used. On the receiver side existing antenna infrastructure can be re-used. This is valid if no change in the channel arrangement is made.

In order to introduce the new technology it can be useful to provide some insight regarding the costs related to such investment. In order to allow for the launch of DVB-T2, broadcast network operators will need to roll out a DVB-T2 transmission network. However, the cost of the network roll out is reduced significantly since broadcast network operators can use their existing transmitter infrastructure including sites, transmitters, masts, and antennas.

Because DVB-T2 targets fixed roof top and portable antennas, as does DVB-T in most countries, it is unlikely that new transmission sites will be necessary. Given that planning parameters do not need to change between DVB-T and DVB-T2, it can be assumed that coverage areas will remain the same unless the broadcaster wishes a change. Consequently, the compatibility guaranteed by the standard DVB-T2 are the following:

- with current transmitter sites;
- present with receiving facilities;
- the planning GE06

The only extra-cost will be those incurred into the replacement of the modulator and multiplexer. An example of cost of such DVB-T and DVB-T2 transmission equipment is provided in the following table:

	DVB-T	DVB-T2
Modulator	10.000 – 12.000 Euro	12.000 – 14.000 Euro
Multiplexer	8.000 – 15.000 Euro	10.000 – 20.000 Euro

According to the table, the price of DVB-T2 equipment is not significantly higher than DVB-T presenting the financial aspect of DVB-T2 as an advantage. The cost of transmission equipment is reasonable when compared to MPEG-2/DVB-T equipment costs. In fact, the cost difference between DVB-T/MPEG-4 and DVB-T2/MPEG-4 transmission equipment is nowadays between 10% and 20%).

DVB-T2/MPEG-4 receivers have been made available in select European retail markets as of 2010. Several consumer manufacturers are currently producing and distributing such equipment thanks to the success obtained in some European countries (notably UK) and worldwide. The new DVB-T2/MPEG-4 receivers are normally backwards compatible with existing MPEG-2/DVB-T standards and hence they will pick up all free to air services on DTT. Hence, DVB-T2 compliant set-top boxes are capable of receiving and correctly displaying digital TV signals transmitted on both DVB-T and DVB-T2 digital platforms, a DVB-T compliant set top box is limited to only receiving DVB-T digital signal and is not capable of correctly receiving and displaying digital TV signals transmitted on a DVB-T2 digital platform.

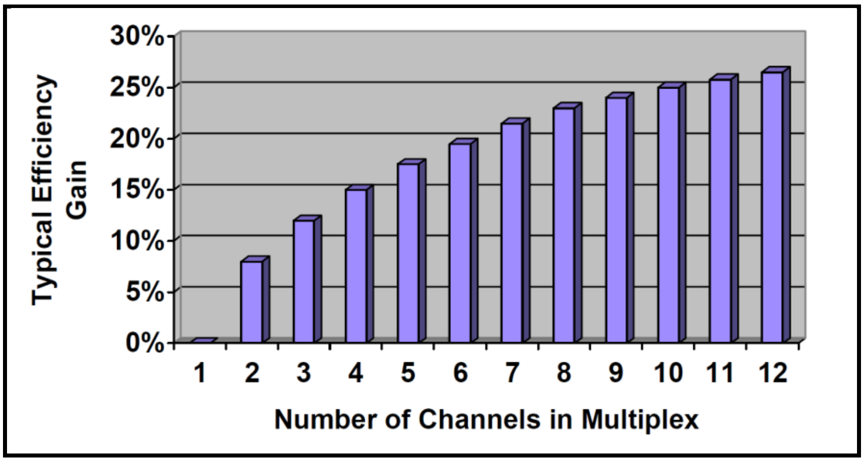
Since the launch of DVB-T2 there has been a drastic decrease of the receiver (both iDTV and external STB) prices. The price difference between comparable DVB-T and T2 integrated TV sets is already negligible. The prices for DVB-T2 external set-top-boxes have already dropped to about 40/50 Euro in UK. By 2015, it is foreseen that also the price difference between comparable DVB-T and T2 STB sets will be almost negligible.

Since ETSI standardized DVB-T2 in September 2009, three countries (Sweden, United Kingdom, and Italy) have launched commercial services using DVB-T2 while several further countries have announced plans to launch DVB-T2 platforms. Outside of Europe DVB-T2 pay-TV services were launched in several countries and many more are expected to follow soon. Advanced trials are currently taking place across the globe and more countries are considering DVB-T2 services, bringing the total of DVB-T2 countries to 47.

3.1.3 STATISTICAL MULTIPLEXING

Statistical multiplexing is based on the assumption that it is fairly unlikely that all programs transmitted by the same multiplex will consist of critical scene material at precisely the same time. Therefore it is conceivable that an intelligent multiplexer will drive the output data rate of the encoders so that the one whose program momentarily makes the highest demands on the MPEG coding process is instantaneously allowed the highest output data rate. This assumption is even truer when the number of independent items of picture information (program data streams) that are added to a transport data stream in the multiplexer becomes larger.

The exact efficiency gain is dependent on both the nature of the video content and the details of the implementation, but gains can be typically expected to asymptotically approach a value between about 25 and 30% for large numbers of channels. The graph in Figure 1 below is indicative of the typical benefits that can be expected, based on statements from encoder manufacturers and the author's own experience:



Number of Channels in Multiplex

The next table summarizes the results in terms of band efficiency which can be obtained with the combination of the above illustrated techniques:

	Mpeg-2 Dvb-T	H.264/AVC Dvb-T2	H.264/AVC Dvb-T2 stat. mux
SD	6-8	10-14	12-18
HD	1-2	4-6	5-7

3.1.4 SFN

With SFN all transmitters utilize the same frequency and exploit the property that if the SFN is properly designed, the received signal components do not produce ISI (Inter-Symbol Interference) but constructively add in the receiver. This effect, usually referred to as "SFN network gain", can be obtained if the SFN transmitters are not too far apart to avoid that the delays of the received contributions exceed the guard interval.

Furthermore, SFN allows for a sharp increase of the spectrum efficiency, since the frequency reuse factor is equal to one in case of SFN. In particular, the SFN approach may be favourable for large service areas (however taking account of the limitation of the maximum achievable network size) and where the same frequency is available across such a large area.

Large SFNs are not suitable for the small local broadcasters because the mux stream transmitted from each SFN transmitter must be identical over the whole service area in order to enable signals to be added constructively at the receiver, so for the small local coverage small SFN networks can be used or just single transmitter per targeted service area. DTT network configuration needs to be optimised with regard to a number of parameters, such as the size of the service area, terrain, population distribution and availability of transmission infrastructure and in particular synchronization of all transmitters in a given SFN network should be performed carefully. COFDM systems have been designed to take benefit from echoes, as long as they enter the guard interval. This condition requires time synchronization of the various transmitters, since the same symbol has to be emitted at the same instant from several places, whatever the time delay introduced by the distribution network. Signals from different transmitters add constructively at the receiver as far as the mutual delay is within the time length of the guard interval. Otherwise, a specific kind of self-interference arises. It follows that, in principle, a longer guard interval (*Tg*) allows to build larger SFNs.

Furthermore, it is often necessary to undertake a large scale frequency re-arrangement to free up such frequencies for national SFNs.

The basic principle of the GE'06Agreement and Plan is that the items (allotments and assignments) recorded in the Plan are internationally coordinated and protected so they can be put into operation as such under GE'06 and RR procedure. Prior to any change to the characteristics of an assignment or allotment appearing in the Plan, or addition of a new assignment or allotment to the Plan, an agreement through the coordination procedure should be sought from affected administration, according to the GE'06 Agreement

When a new co-ordination request concludes positively, the item co-ordinated can become part of the Plan with the same rights. In case of a new co-ordination request, if an agreement is not reached among the concerned administrations, administrations can invite ITU to assist in solving the controversy among the ITU State Members. This means that GE06 Agreement allows some flexibility and that evolution of GE06 Plan can accommodate new frequencies per allotment, or even new transmitters (assignments), but in the same time does not allows putting into operation any new assignment prior to the successful conclusion of the coordination procedure with concerned administrations under the provisions of GE'06 Agreement and RR.
The exact procedure for modifications to the GE-06 plans and putting into use assignments is given in Article 4 and 5 of Geneva 06' Agreement.
(http://www.itu.int/ITU-R/terrestrial/broadcast/plans/ge06/flowchartsGE06/article%204%20flowchart-BC-ver5.8-final.pdf).

The European Union (EU) has been encouraging SFN deployment despite resistance from some member states, holding workshops on the subject, while the European Broadcast Union (EBU) has published guidelines for implementation. Most European countries have implemented SFN networks. For example the national DTT networks utilize mainly SFN. Finnish DTV operator DNA has become one of the first in the world to set up a DVB-T2 terrestrial infrastructure using a single-frequency network (SFN) configuration. Several other European operators also are working on SFN deployment, including Portugal Telecom, which has been implementing SFN across a national network comprising more than 100 transmitters.

3.2 Digital Dividend as a major Objective

Availability of radio spectrum is a clear enabler for economic and social growth. This illustrates why it is vital that the next opportunity to provide the much needed wireless bandwidth, the 'digital dividend', is managed as efficiently and effectively as possible to ensure the maximum benefit for all.

If the digital dividend is managed as efficiently and effectively as possible, the range of uses to which it can be applied will be wider, with potentially more wireless applications having efficient access to this valuable resource. Of all the applications, the category of electronic communications is the most promising. These applications include wireless broadband communications providing ubiquitous broadband access for all, additional terrestrial broadcasting services and mobile multimedia applications.

In social terms, making the digital dividend available for broadband, alongside spectrum in other bands, can help close the digital divide. Overall, the Internet usage will be nearly four times larger in 2013 than in 2009, while mobile data and Internet traffic will more than double every year in Europe.

Additionally, the modern consumer and service subscriber are becoming more mobile and no longer accept limitations in applications and accessibility to content. As the demand for bandwidth to deliver ICT applications explodes, growing much faster than the current expansion of wireless networks, consumers need to be provided with appropriate access to delivery mechanisms to meet their needs. The "digital dividend" band could thus complement other mobile broadband frequency bands.

DVB-T2 is a facilitator for digital dividend because it allows better spectrum efficiency compared to old DVB-T. Such spectrum efficiency shall be used to facilitate the implementation of digital dividend.

In the Radio Spectrum Policy Programme (RSPP) the Member States and the European Parliament decided to mandate the opening up of the 800 MHz throughout the EU by 1 January 2013, on the basis of the conditions of se specified in the existing EC Decision to harmonize the 800 MHz band.

By 1 January 2013, Member States shall carry out the authorization process in order to allow the use of the 800 MHz band for electronic communications services. Many European countries (Sweden, Germany, Italy, France, etc.) have already conducted the auctions for the 800 band in order to make available such band for broadband mobile services.

Other common objectives

All countries will share the following objectives: technological integration; introduction, deployment and promotion of the use of digital and broadband services (lowering digital divide), adoption or migration to more effective technologies (maximization of digital dividend).

3.3 OBJECTIVES FOR EACH GROUP:

As detailed later in this report, we will advocate that innovative technology such as DVB-T2/MPEG-4 is used for DTT the whole SEE Area, but since the different SEE Countries show a different stage in the digitalization process, each Country will have other specific goals to reach and different timelines to respect:

- **GROUP A (Croatia, Slovenia, Austria, Hungary and Italy):** Migration to more effective technologies, commercial development of DTT services, digital dividend (1 and 2) allocation.
- **GROUP B (Albania and Macedonia):** Speeding up the digitalization process, ASO, migration to more effective technologies;
- **GROUP C (Serbia, Bosnia and Herzegovina, Montenegro):** Introduction of DTT, definition of a stable regulatory framework for digitalization**,** timeline to ASO.

3.4 Technology migration improvements

Adopting more efficient technologies (MPEG-4 and DVB-T2) will bring on the DTT platform significant benefits for consumers, citizens. To be attractive to consumers, DVB-T2 can be used to introduce new (potentially HD, 3D TV) services alongside, and in addition to, existing DVB-T services. The migration process will promote investment and innovation, to serve the interests of consumers in respect of choice, price, quality of service and value for money, and to further the interests of citizens. The adoption of these technologies would substantially improve the efficiency with which spectrum is used by DTT in the short, medium and longer term.

3.5 STRATEGY FOR GROUP A

Croatia, Slovenia and Austria have successfully launched DTT services and ASO has already been achieved. In these countries most transmissions use DVB-T and MPEG2 /MPEG-4 (MPEG-4 H.264 is used by Slovenia and partly in use in Croatia, Hungary and Italy). Trials and testing of DVB-T2 has already started with planning to use DVB-T2 in the next years. Croatia has already issued a license for two DVB-T2 networks, multiplexes MUX C and MUX E, which will be used for Pay-TV services.

Italy and Hungary have digitized their countries and ASO is imminent in Italy (June 2012). Italy already utilizes a commercial DVB-T2 mux and many trials are actually in course.

The main objective for each of these countries is to migrate to more efficient technologies (MPEG-4/DVB-T2) and hence make a more effective use of the broadcast spectrum to launch new services like HD/3D and/or to rationalize spectrum efficiency to allow new services like mobile broadband in order to implement the digital dividend.

3.5.1 Group A: A gradual transition - Two Options

This section outlines some aspects relative to the migration strategy that are common to all countries in group A. It is a shared view that this migration should be based on there being additional offers to the consumer in order to be successful. These offers may consist of additional services or may consist of different service types, such as HDTV and even 3D TV. The technology migration strategy should hence enable new services to be offered, using new technologies, without having to reduce the availability of existing services using existing technologies.

In general terms, the introduction of the new technology should be gradual. In fact, the new technologies need to be deployed in a way that helps to avoid displacing existing services from the platform - so that viewers with existing equipment are not disadvantaged. If a complete and instantaneous switch from DVB-T to DVB-T2 were adopted, there is the risk that consumers will object to being forced to buy yet more new technologies soon after the first digital switchover and could change platform (satellite or IPTV). This is why it is recommended that the overall technological process be gradual for all countries. The gradual aspect of this migration process implies that a simulcast period, similar to that required for the transition from analogue TV to DVB-T, will be needed for this technology transition. The length of the simulcast period will largely depend on the relevance of the terrestrial platform as compared to other platforms. The higher the terrestrial penetration the more care needs to be taken with the transition, and in general, more time will be needed.

For countries that have already switched to DTT the issue of consumer reinvestment becomes an issue. The introduction of DVB-T, perhaps within the last ten years, was accompanied by the need for consumers to invest in new receiving equipment. Now, with the migration to DVB-T2, a new investment in receiving equipment is required by the consumers. This is a difficult situation since consumers have been used to longer renewal cycles of TV receiving equipment. The choice of the duration of the migration to DVB-T2 has to be selected carefully in order to avoid losing viewers to other platforms, as happened in some countries with the transition from Analogue TV to DVB-T. On the other hand, transition should not be to long because of the risk of losing the strategic advantages deriving from the introduction of new advanced services such as HD and 3D TV, which can be more easily deployed on alternative platforms like satellite and IPTV.

A second aspect of the migration strategy with is common to all countries of Group A relates to the possibility of following two different approaches in introducing the more efficient technologies as MPEG-4 and DVB-T:

- two step upgrade which means introducing previously MPEG-4 and subsequently DVB-T2 ;
- "one-shot" approach where the two technologies would be introduced simultaneously.

A two step upgrade in relation to consumer equipment imposes significant unnecessary equipment costs on consumers and provides fewer benefits in terms of services on DTT now and in the future. Avoiding a two stage upgrade and the substantial downsides that this involves, requires the upgrade of multiplexes to be both MPEG-4 and DVB-T2. This also plays an important role in fostering rapid adoption (to the benefit of both consumers and the platform) as this will allow a greater number of services to be offered using the new equipment.

Finally, it has to be considered that once adoption of DVB-T2 receivers has become almost universal, an upgrade of existing DVB-T multiplexes to DVB-T2 operation could be relatively painless to consumers.

The migration strategy should also be differentiated according to the particular country situation in terms of DTT roll-out and DTT spectrum usage. A first possibility (Option 1) is that one (or several) multiplexes should be cleared of existing services in order to be upgraded to the new technologies, MPEG-4 and DVB-T2. The resulting DVB-T multiplexes will show a more compact aggregation of services at the end of this process (with a possible slight loss of quality). The cleared multiplex(s) will be operated using the new technologies (i.e. DVB-T2 + MPEG-4). In this case the number of multiplexes before and after the migration would remain the same with the difference that n-1 mux would comply with the old technology (DVB-T) and would carry all the existing services whilst the cleared mux would be based on DVB-T2/MPEG-4 and would carry advanced services such as HD or 3D or different services (Premium, pay-tv, etc.). As already previously stated it is recommended that on the cleared mux DVB-T2 and MPEG-4 should be introduced together, to reap the combined benefits and to avoid a proliferation of different types of consumer equipment for free-to-air DTT services. This option would fit well to countries (like Italy) where spectrum is overcrowded and hence other strategies based on spectrum are not possible.

A second possibility (Option 2) requires unused and/or additional spectrum to be utilized for the roll-out of additional mux enabling the new technologies. A first possibility can be derived for countries which have already planned a certain number of multiplex (n) for the realization of their DTT network but so far only a part of such mux (m with m < n) have been deployed and use DVB-T. Examples of such countries are Austria and Croatia. In Austria 6 mux have been planned for DTT: Mux A, B, C, D, E, and F. Whilst three mux have already been deployed and use DVB-T , Mux A and Mux B for National services, and Mux C for local services, the other 3 mux have not come into operation. In 2011 Austria Media Authority KommAustria announced the creation of two new nationwide DTT multiplexes. The multiplexes MUX D and E will use the DVB-T2 standard in line with our recommendation and also MUX F is tendered. Also Croatia has followed a similar approach. In fact so far Croatia DTT services have been divided among 3 Multiplexes: MUX A which includes PBS (HRT1 and HRT2), commercial TV channels (NOVA and RTL) and My Administration Channel; MUX B: which includes PBS (HRT3 and HRT4) and commercial TV channels (DOMA and RTL2)) and MUX D: for local, regional and three national coverage thematic channels; music (CMC), sports (SPORTSKA TV), business news (KN). The original DTT planning foresaw additional four mux. After the tendering procedure in October 2011 HAKOM issued a license for two DVB-T2 multiplexes to the national consortium (HP Produkcija, OIV and Croatian Post).The consortium will operate two DTT multiplexes (MUX C and MUX E), employing DVB-T2 technology and each eventually, in year 2014, covering at least 94% of the population of the country.

Additional spectrum to be used by DTT mux can also be found in alternative ways like temporarily unused spectrum, available perhaps in countries where DVB-H is regarded as not being successful. Other countries might even use available VHF spectrum for this purpose.

Finally, a last opportunity could derive from an ex-novo frequency planning based on more efficient spectrum techniques as SFN. In this case the SFN planning could reshuffle the planned DTT frequency based on MFN and due to the improved efficiency some more mux could be available for the new technologies.

With SFN a very sophisticated re-planning is needed in order to correctly assess information for each transmission site, and transmit delay optimization for synchronized networks. This can only be accomplished by using specialized software that allows simulating the propagation effects.

It is important to consider that there are a series of disadvantages are linked to this option, as:

- Need to re-plan the existing DTT network (previously MFN-planned) ;
- Complexity of reorganizing all mux;
- Consumer disturbances.

Hence, the decision to implement SFN networks depends from the particular situation of each country and hence such decision should be left to each competent authority in each country together with broadcasters and network operators, depending on their own national characteristics (such as topology and geography) and their own national objectives.

3.5.1.1 Planning of Option 1

First, it is suggested that that the selected multiplex which will be cleared from existing services should be the one presently carrying the fewest services on the platform, in order to minimize the scale of platform reorganization. Another possibility would be to select the PSB Mux. Furthermore, a rationalization in the capacity utilization of the DVB-T mux should be conducted. Sufficient space for the existing services of the to be cleared mux should be found on other existing mux(s) either by compressing/reducing bit-rate for some existing services on other existing mux(s) and/or by identifying not-fully utilized mux(s) where additional capacity may more easily found.

The result of such planning would be a reorganization of the actual contents on other multiplexes. Statistical multiplexing should also be imposed on all DVB-T multiplexes because it allows a better utilization of the mux capacity. If this option is chosen it is strongly advised to conduct a public consultation with all interested parties on the following subjects in order to further develop and define the following points:

- Identification criteria for the multiplex(s) to be cleared and upgraded to the new T2 technology;
- Reorganization of other existing multiplexes to absorb services displayed from the cleared multiplex;
- The identification of possible means to accomplish the previous step (statistical mux obligation; obligation for the mux operators to use more efficient DVB-T transmission equipment; bit rate reduction to downgrade quality of existing services in order to create sufficient capacity to accommodate services from the cleared multiplex, etc.);
- Allocation of cleared multiplex (allocation for enhanced format services as HD or 3D, etc.).

A permanent working table devoted to the T2 migration should be set with all involved interested parties as: manufacturers, multiplex operators, broadcasters, consumer associations, etc. in order to monitor the status and the results of the migration. An observatory should monitor the “watching” consumer preferences and the “buying” user habits. Results should periodically be used to estimate the penetration of standards on the total of receivers sold.

The transition period should last for a reasonable amount of time (5-7 years) to allow the "natural" migration of users between the two technologies.

Before converting all the remaining DVB-T mux(s) to DVB-T2/MPEG-4, an information campaign should be conducted in order to facilitate consumers to acquire DVB-T2/MPEG-4-compliant receiving equipment. This campaign should stress the advantages coming from the conversion, taking into account in particular the HD/3DTV feature. Subsidies could be envisaged for the weaker population segments to acquire the new DVB-T2/MPEG-4-compliant receiving equipment.

3.5.1.2 Timeline of Option 1

A tentative schedule of the overall technology migration could be**:**

Date x: Obligation: Mpeg-4/DVB-T2 mandatory for all future licensing and obligation to commercialize in that particular Country receiver equipment with DVB-T2 tuner and mpeg-4 capability.

+ 3 months: NRA (National Regulator Authority) to set a public consultation on a draft migration strategy. Such migration strategy should contain sections devoted to: commercial and technical matters, criteria for identifying the mux(s) to be cleared, reorganization of services, capacity allocation, etc.;

+6 months: After publishing the results of the public inquiry the NRA (National Regulator Authority) or equivalent body to select number of mux to be cleared (with new technology), DVB-T mux capacity re-organization, simulcast time duration, etc..

+ 9 months: The NRA or equivalent body defines the content selection process for the cleared mux.

+ 12 months: Kick-off of the cleared mux with new services with DVB-T2 and mpeg-4 technology.

+ 15 months: Permanent working table devoted to the T2 migration should be set with all involved interested parties as: manufacturers, multiplex operators, broadcasters, consumer associations, etc. in order to monitor the status and the results of the migration and to decide on additional mux conversion to the new technology.

+ 15months: Observatory to monitor new standard sales and penetration figures for DVB-T2/MPEG-4 receiver equipment;

+ 5 to 8 years : Switching of remaining DVB-T multiplex to new technology

3.5.1.3 Planning of Option 2

For countries where it is possible to roll-out additional mux (additional spectrum can be used for DTT other than the present one), the DVB-T2 standard should be imposed initially only for such additional mux. New MUX selection criteria should also be carefully established by the NRA. Furthermore a planning exercise has also to be considered in order to define the requirements for the additional offers to be placed in the new mux. These offers may consist of additional services (premium or pay) or simply offering enhanced formats (HD, 3D TV) of existing contents on the “conventional” DTT mux. SD and HD simulcast could then be considered because the new HD receiving equipments should be able to work both with DVB-T and T2 (DVB-T2/MPEG-4 receiver equipment normally supports both HD and SD. By doing that, the users equipped with DVB-T receivers could receive the entire SD offer whilst users equipped with T2 equipment could benefit from more advanced formats as HD and 3D further to the "standard" offer of the DVB-T mux. This process would lead to a "natural" migration of actual DTT/DVB-T users to acquire T2 equipment.

A permanent observatory monitoring the “watching” user preferences and the “buying” user habits in terms of receiving standard should be set up in order to estimate the penetration of standards on the total receivers sold. After a reasonable period of time and based on the data also the “old” DVB-T mux should be converted to the new T2 technology.

3.5.1.4 Timeline of Option 2

A possible schedule could for this option follows:

Date x: Obligation: Mpeg-4/DVB-T2 mandatory for all future licensing and obligation to commercialize in that particular Country receiver equipment with DVB-T2 tuner and mpeg-4 capability.

+ 3 months: NRA (National Regulator Authority) to set a public consultation on the following matters:

- New MUX selection criteria
- requirements for the additional offers to be placed in the new mux. (HD, 3DTV, etc)
- SD and HD simulcast

+6 months: The NRA or equivalent body to select number of mux with new technology and frequency plan for the new mux;

+ 9 months: The NRA or equivalent body defines the Mux selection process.

+ 15 months: Kick-off information campaign.

+ 15 month Beginning of gradual switch-off.

3.5.2 DIGITAL DIVIDEND ALLOCATION

As already stated a digital dividend strategy should be adequately considered for the countries in the Group A. In fact availability of radio spectrum is a clear enabler for economic and social growth due to the following factors:

- more wireless applications having efficient access to this valuable resource;
- can help close the digital divide.

Some countries of Group A as Italy and Austria have already conducted significant steps. In particular Italy has already conducted the auction bid for the granting of the "external" Digital Dividend (800 MHz band) to TLC operators.

Slovenia is a EU country and Croatia is set to become the 28th Member State of the European Union on 1 July 2013, this means that Decision No 243/2012/EU of the European Parliament and of the Council of 14 March 2012 establishing a multiannual radio spectrum policy program will apply also to these countries. Another factor to be considered is that by 2013 most European countries, which are in many cases neighbor to Slovenia and Croatia, will have implemented the digital dividend.

Hence, it is advisable for all countries belonging to Group A to start planning activities for the creation and allocation of the digital dividend since most EU counties and several of their neighbors have already implemented it.

3.5.2.1 Digital Dividend Auctions:

It is advisable for SEE Countries that will start planning the digital dividend allocation, to follow the procedures already put in place in other countries where similar auctions have been conducted successfully.

Countries which are going to implement the 800 band digital dividend should refer to the Commission Decision of 6 May 2010 on "Harmonized technical conditions of use in the 790-862 MHz frequency band for terrestrial systems capable of providing electronic communications services in the European Union which defines general technical conditions relative to channel arrangements as block sizes, duplex spacing, technical conditions for FDD and TDD. These Countries can also take advantage of contest regulations already set by EU countries which have already completed the auction phase (e.g. Germany, Spain Italy, etc.) regarding auction features as for example: - type of auction procedure - cap mechanism- block dimensioning - participants obligations (coverage start-up of the service) - asymmetrical rules- digital divide requirements.

Finally, it is also recommended that Group A countries take into consideration the "second digital dividend" because of its consequences on broadcasting spectrum utilization. In fact WRC-12 agreed to allocate the 700 MHz band (694-790 MHz) to mobile broadband on a co-primary basis with the existing broadcasting services in the band after the next WRC in 2015. However, the agreement at WRC-12 does not mean that the 700 MHz band will be immediately available in Europe for mobile broadband from 2015, since the spectrum is being heavily used for terrestrial television broadcasting. It will be up to each country in region 1 to decide whether to move broadcasters out of the 700 MHz band.

3.6 STRATEGY FOR GROUP B:

In **Albania and Macedonia** some commercial pay-tv DTT services have been initiated and sales of DVB-T receiving equipment are significant. The main objective for both countries is to speed up the digitalization process for FTA services and reach ASO.

3.6.1 Group B: Speeding up the digitalization process, switch off,

In Albania, the introduction of DTT services has been operated by one single private operator (DigitAlb), and we see the presence of PAY DTT services and no FTA DTT.

As for Macedonia we have the presence of one single company, Telecom Slovenije, owner of both the TLC end (One) and the Broadcast (BoomTV). Although procedures have been followed by the operator, the result is that there is no FTA DTT offer in the country.

For these Countries not only the introduction of FTA DTT is necessary to allow the switch off of analog transmissions, but DTT shouldn't be solely a "Premium" platform: it has to be available to the whole population. In these two countries, the development of new services and the improvement of quality standards must increase the level of pluralism and of competitive environment.

On the other hand it is very important that the PSBs become the initiators of the transition by broadcasting a simulcast of their programs in digital, and progressively switch off the analogue transmission.

As transition to digital of these programs will happen, space will be created both for FTA and PAY operators to continue their commercial development. Particularly in Macedonia, this can be possible since Telecom Slovenije is also owner of One, the country's second TLC operator, which will benefit from the distribution of the digital dividend.

An alternative, to allow the launch of a DTT FTA offer, could be the hosting of the PBS channels and the commercial channels already present in the analog transmission on the MUX operated by DigitAlb and Telekom Slovenjie at a cost-oriented price. In such a way even consumers owning DVB-T equipment would be able to receive PSB digital services.

To prepare the grounds for the development of the DTT platform as a whole, it is very important to provide the appropriate legal framework and introduce a complete regulatory framework for the introduction and development of additional FTA services. It is recommended to follow the same rules and principles which have been set for Group C Countries (see paragraph 3.7) and that the FTA offers should immediately introduce DVB-T2 (together with MPEG-4) because of T2's significant benefits and gains over all other DTT transmission systems available. The peculiarity of these Countries with respect to Group C countries is that there are already a number of DVB-T receivers that have been sold. It will be up to the pay-tv operators to decide when switching to new

DVB-T2 on the basis of their commercial requirements. In any case by the end of switch-off even the existing commercial pay mux should switch to the new technologies.

3.7 STRATEGY FOR GROUP C:

A common strategy can be defined for countries where the digitalization process has not formally or effectively been initiated, like **Serbia, Bosnia and Herzegovina, and Montenegro**. Bosnia and Herzegovina and Montenegro are countries where the transition to DTT is still in a very early stage (transmitting equipment procurement, trials only or similar activities). Even Serbia has only recently announced that it would go straight to DVB-T2 for its DTT Network and is starting to offer DTT services only recently.

It is important that the final switch-off date be fixed and communicated widely to the public in an attempt to give enough time for people to familiarize themselves with the digitalization process.

The role, funding and remit of the national PSBs should be (re)defined to ensure their active and mobilizing position in the ASO process and the continuation of the provision of the FTA PSB channels along with the new services.

3.7.1 DTT Migration process: one-shot vs. phased approach

In order for the migration process to begin, the DTT planners need to prepare a timetable detailing when analogue transmitters will be switched-off throughout the Serbia, Bosnia and Herzegovina, and Montenegro. Migration can be planned in two ways: one-shot migration, where a date will be set to switch-off the analogue television broadcast signal throughout the Countries and the phased approach where the migration is gradual with a period of simulcast of analogue and digital signals.

The simulcasting of existing analogue services should last until the ASO is achieved. This is advisable because TV viewers would be incentivized to migrate to DTT because of a richer digital offer compared to the analogue one. In fact, through simulcast the new digital offer would include as a minimum the existing analogue offer (with the enhanced features of the digital technology as better image quality), integrated by new digital channels (even with enhanced formats as HD or premium contents for Pay-tv). It is worthwhile to mention that in most countries analogue channels have not undergo the selection process (Beauty contest or other) to access the DTT platform but have automatically received license/authorization to operate in digital. In most countries where ASO has been successfully achieved the adopted strategy has included simulcast.

The phased approach provides several benefits over the one-shot migration. With the phased approach the lessons learned in one region could be used to improve the process in another region and if something goes wrong, the problem is limited to a single area. Secondly, the released frequencies can be re-used in a neighboring region in order to increase its DTT coverage and expand the DTT service offering. Finally, this approach allows DTT planners to spread the cost and make the effort of digitalization more manageable. Therefore, the phased approach is recommended for the Countries where the process has not been initiated, like Serbia, Bosnia and Herzegovina, and Montenegro.

3.7.2 DVB-T2 and MPEG-4

For all countries that have not yet started their transition to DTT, it seems logical that they should immediately introduce DVB-T2 (together with MPEG-4) because of T2’s significant benefits and gains over all other DTT transmission systems available. Switch-over could be planned by launching a pilot test utilizing existing available frequency resources. An experimental DTT test phase should start as soon as possible. It is also recommended to choose the first test-trial locations in densely populated areas to make as many people as possible aware of the advantages and benefits of digitalization.

These countries should hence make Mpeg-4/DVB-T2 mandatory for all future mux licensing and set the obligation to commercialize receiver equipment with DVB-T2 tuner and MPEG-4 capability.

3.7.3 CHANNEL SELECTION PROCEDURE

From a regulatory point of view two distinct approaches can be used for channel (program) selection. In the first approach the channel line-up is a result of a selection made directly by the Broadcast Regulator or the Government through public procedures (“beauty contests”). This mechanism allows the highest degree of control over the platform composition because administrations can exert more influence in the assignment process thus ensuring that certain policy goals are fulfilled. An example of such policy goal could be to favor pluralism and to take into account the needs of non-majority communities and vulnerable groups.

The administration running the “beauty contest” will look at the following list of criteria that the applicants should meet:

- The ability to meet the needs of a wide public and likelihood to engage in rapid development of digital terrestrial television;
- The need to ensure effective competition and diversity of operators;
- Safeguarding media pluralism, socio-cultural diversity, needs of minorities, vulnerable groups, etc.;
- Experience in the media sector;
- Commitments on production and distribution of audiovisual and cinematographic works;
- Liabilities for the coverage of the territory;
- Coherence of proposals for consolidation of distributors and choice of services;
- Funding and prospects of service provision;
- Coherence of the proposal in terms of grouping and service distribution (pay vs. free, current agreements for Mux management, etc.);
- Operator’s financial plan.

The proposal for channel selection should provide some safeguards for existing programmes transmitted by the analogue network, in particular for the public broadcaster. Usually, the existing analogue programs do not have to undergo the selection procedure on the condition that their license was obtained before the selection procedure has been initiated. As a result, these channels/programs are then included by default in the digital channels line-up. It is possible, however, that the analogue channels transferred to the digital channel line-up may be requested to perform simulcast at least during the transition phase.

3.7.4 NETWORK/MUX SELECTION PROCEDURE:

Groups C (Serbia, Bosnia and Herzegovina, Montenegro) countries will be faced with the need to adopt procedures for the selection of MUX operators as well as for the allocation of capacity to broadcasters.

To guarantee transparency, non-discrimination and fair competition, it is recommended that all the countries here above adopt a comparative procedure. A "beauty contest" procedure for Mux selection seems better than an auction. In fact, beauty contests enable administrations to exert more influence on the assignment process than through auctions, thus ensuring that specific policy goals are fulfilled. The comparative procedure would not be damaging to the existing operators who have already invested in building analogue infrastructure. In fact, some "beauty contest" criteria (e.g. technical experience and technical planning for network deployment) would favor existing operators with consolidated experience in the terrestrial television sector. Finally, in the case there are only a few bidders interested in obtaining MUX management, beauty contests are considered to be more suitable to ensure a more efficient use of the spectrum.

The "beauty contest" should define several rules and conditions about:

- participation requirements;
- form and deadline for the presentation of tenders;
- admission and exclusion conditions. Pre-selection may also take place with the aim of verifying the suitability of candidates by checking for example their financial capability, legal form and ownership structure. assessment criteria (for example applicant experience, financial aspects such as solidity or credibility of the business plan proposed, its technical quality, etc.);
- obligations of the holder of the rights to use frequencies (e.g. coverage obligations in terms of population to be covered during certain period);
- criteria to form the evaluation Commission;
- any asymmetrical conditions (for example in case the competition equilibrium in the DTT market has to be re-established).

3.7.5 Other Measures to facilitate migration to DTT in GROUP C:

It is advised that all existing national analogue channels should not undergo the selection process (Beauty contest or other) to access the DTT platform but should automatically receive license/authorization to operate in digital.

3.7.5.1 Consumer awareness campaigns

Not only TV advertisements have proven successful in increasing consumer awareness about DTT migration, but some other means can be utilized as well.

For example call centers are particularly useful during the switch-off. They can be used to get practical information such as switch-off dates and solving of specific reception problems.

Direct mail sent to households is a further mean to inform viewers about the impending switch-off. Another important source of information about the transition can be the equipment distributors and antenna installers themselves, as they are in direct contact with end-users..

Finally, Websites with information on digital switchover can be set up to provide answers to questions such as switch-off calendar, accurate coverage maps, contents, Mux structure etc.

Print and TV advertising are best used at an earlier stage to announce the coming of DTT, whereas events, brochures and direct mail are more suitable to bring more detail once the transition starts. Assistance through the Internet, call centers and support from installers and technicians should be available when switch starts and long after it has been completed.

3.7.5.2 State benefits for the weaker segments

The comparative analysis of state policies for supporting the switch to digital TV, highlights how all the main European countries have provided some kind of system for assisting the weaker population groups, particularly for the elderly, those with disabilities or with low incomes.

General subsidies for all households should not been allowed because of neutrality and non-discrimination principles (discrimination towards other television platforms, such as satellite and IPTV). Support, which in some cases could include specific financial subsidies, targeting non-majority communities and/or people with disabilities should be allowed.

Initiatives that can be put in place span from assistance to families who risk being excluded from the transition to digital process, to home assistance for certain population groups, including installation of a receiver and a practical demonstration of how to use it. Some specific population categories, like the elderly or with a disability can be made eligible for a free receiver or made exempt from paying the TV license.

To help transition and the lowering of the digital gap, one or several of these initiatives could be implemented.

3.7.6 TIMELINE FOR THE ROADMAP FOR ASO FOR GROUP C AND FOR THE SPEEDIG UP OF THE DIGITALIZATION PROCESS OF GROUP B

Group C is at an earlier stage of the digitalization process than Group B, the "Date x" of the two groups is obviously different, Group B has already passed the first phase. That said, after the first phase is implemented also by Group C, the two groups could follow a very similar process.

GROUP C:

Date x: Pilot-test and DTT trials (DVB-T2/MPEG) to start through a simulcast with existing analogue channels.

GROUP C AND GROUP B:

ASAP: Obligation: Mpeg-4/DVB-T2 mandatory for all future licensing and obligation to commercialize in that particular Country receiver equipment with DVB-T2 tuner and mpeg-4 capability..

+ 3 months: The NRA (National Regulator Authority) or equivalent body defines a DTT regulatory framework for digital terrestrial television, containing S/O date, rules and dispositions relative to authorization titles for content and service providers and network operators, provisions for line-up selection, and Mux selection.

+6 months: The NRA (National Regulator Authority) or equivalent body performs DTT line-up selection.

+ 9 months: The NRA (National Regulator Authority) or equivalent body defines Mux selection process and the DTT numbering plan.

+ 9 months: The NRA (National Regulator Authority) or equivalent body defines the DTT frequency Plan based on DVB-T2.

+ 15 months: Kick-off information campaign.

Between 9 and 12 months Beginning of gradual switch-off.

2015: Completion of analogue switch-off according to ITU

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1 ANNEX 1: Overview of New Technologies and Services

1.1 BROADCASTING ENHANCED FORMATS

1.1.1 HDTV

HDTV stands for High Definition TV. HDTV allows the user to view larger and sharper images than standard television (or SDTV, Standard Definition TV). The image of the television is generated by a series of dots (or pixels), the greater the number of points (spatial resolution of the image defined as the total number of pixels) the greater the image definition. The first advantage of HDTV is having a definition double or triple compared to SDTV. The standard television (SD TV) has a resolution of 720x576 pixels (for PAL, the European standard, where 576 is the number of active lines) and 720x480 (for NTSC, the American standard, where 480 is the number of active lines). These two resolutions are identified simply as 576i and 480i.

HDTV has a resolution of 1280x720 pixels or 1920x1080 pixels. These resolutions are called 720p and 1080i or 1080p. The "i" and "p" identify the type of the final image scanning: interlaced and progressive. The traditional cathode ray tube TVs are usually interlaced scanning.. The image is constructed in two steps: first all the odd lines, then all the even lines. The modern computer monitors and televisions lcd and plasma support progressive scan, i.e. the image is composed in a single step.

HDTV services offer notably higher picture quality than the traditional 'standard definition' television (SDTV) services. Instead of providing an image with 576 active lines, as is the case of '625 line' SDTV in Europe, HDTV provides an image with a format of either 720 or 1080 active lines on the screen. Motion portrayal may also be better than traditional SDTV depending on the whether the active lines form a progressively scanned picture fifty times a second, rather than a complete interlaced image twenty five times a second.

To transmit the increased amount of data necessary to adequately carry the more detailed images, HD services require more bit rate capacity than SDTV ones. Greater bit rate capacity translates effectively into more frequency spectrum requirement

Another advantage of HDTV is that the source of the signal is always digital (digital TV, computer, console, etc.). The analog signal is subject to interference from distance or cables, with digital the quality is higher. Finally, the proportion (or aspect ratio) between height and width of the screen HDTV is 16:9 against the most common 4:3 SDTV. The 16:9 format is better suited to film, so the viewer can enjoy the film without risk of losing portions of images.

Summarizing the advantages of HDTV are: higher resolution and better image definition, higher quality digital signal, widescreen 16:9 images closer to cinema format.

The most common resolutions for HDTV are 720p and 1080i. It is possible to obtain even 1080p which would provide the highest possible quality for high definition, but few TVs support it, and however the amount of information to be transmitted is such as to make the transmission problem.

With a resolution is 720p a clear and firm image as that of a computer monitor is obtained . The 1080i has a higher pixel resolution, but has the typical flickering of the standard television picture tube.

The resolutions supported are those that the TV will be able to transform. A screen 1024x768 will display images always with such this definition even if the source sends a signal less (ie PAL SD, 720x576) or higher (eg: 1080i, 1920x1080). If the resolution entrant will be less than that of the screen, a scaler will upscale (or upsample) signal, which will calculate and create all the information (the pixels) are missing until you arrive at the correct resolution. If on the contrary the scaler receives more information than the video to be able to view, part of the signal should be discarded. This process involves a deterioration of the image is therefore desirable to always display the video at the native resolution of HDTV.

The following table shows the comparison between SDTV and HDTV:

TV FORMAT	Spatial resolution	Image Ratio	Image scan	Temporal resolution	Ratio HDTV/SDTV spatial resolution	Ratio HDTV/SDTV temporal resolution
SD TV 720x576	720x576	4:3	25	25	-	-
HD TV 720p	1280x720	16:9	50	50	2	2
HD TV 1080i	1920x720	16:9	25	25	5	1
HD TV 1080p	1920x720	16:9	50	50	5	2

1.1.2 UHDTV

The International Telecommunication Union (ITU) has recently (end of 2011) revealed new technical specifications for Ultra High Definition Television (UHDTV). A group of global experts, working as the ITU Study Group on Broadcasting Service ITU-R Study Group 6, have reached at the end of 2011 an agreement on most of the pertinent technical characteristics of the new standard for television. The UHDTV promises an increased screen resolution to around 33 million pixels (7690 by 4320) which is about 16 times the resolution of current HDTV.

1.1.3 3D TV

3D television has the purpose of reproducing the sensation of images in three dimensions as happens in real life. The "stereoscopic" effect is the perception of the visual field and three-dimensional objects as a result of binocular vision". In fact, the two images collected separately from the left eye and right eye in the brain come together in a single image. The monocular or monoscopic vision is not sufficient to do appreciate the depth or third dimension. In order to reproduce the stereoscopic effect with the binocular vision it is necessary to take two images of the same subject from the same distance, but with lateral movement, like that of the eyes.

To get the 3D view it is required to use a 3D television set, 3D glasses and a STB appropriate to the display system of the TV monitor. The visualization of the images can be frame-sequential, associated with the use of active shutter glasses or polarized in alternate rows, associated with the use of passive polarized glasses There are several types of 3D televisions on the market. Those destined to encounter more favor with the public use active shutter glasses.

The active-shutter glasses must be synchronized with the television screen to allow each eye to see the correct image at the precise moment. These 3D TVs feature a built-in infrared (IR) emitter and will also support the fast picture refresh speeds that are needed for active shutter 3D glasses. The primary advantage of active-shutter 3D HDTVs is their ability to show high-definition images and the price premium over a 2D-only TV is often less than $200. The primary disadvantage is the relatively high cost of eyewear at $50-$150 per pair.

Passive 3D HDTV features a film layer on the television screen with two pictures polarized to match a special set of glasses. The lenses in the eyewear are each polarized differently to only reveal one view (left or right) of the picture the TV is showing. Thus, the glasses are not much more complicated than your typical pair of sunglasses. The main advantage of the passive 3DTV is that the glasses are relatively inexpensive, costing between $1 and $5 per pair. The disadvantage of the passive system is that the polarizing film (referred to as pattern-retarder or X-Pol, or micro-polarized) on the front of the screen also adds cost to the TV, so these models are higher in price.

For the transmission of stereoscopic camera left and right two types of techniques can be considered: Frame Compatible and Service compatible:

- Frame Compatible systems use the same sequence of pictures and lines, ultimately the same infrastructure used to transmit HDTV 2D-focusing two images L and R in a single panel with the bottom-up system that halves the vertical resolution or the system side-by-Side that halves the horizontal definition. The 3D TV transmission systems have the advantage Compatible Frame to use the same decoder 1080i HDTV (naturally followed by a 3D TV), but at the expense of image resolution that is halved. The Frame Compatible signal, however, is only usable by a 3D TV, while TV is unwatchable with a normal 2D. 3D-enabled televisions differ from 2D-only sets in their electronics and either the addition of an emitter to sync the signal (for an active-shutter set) or a polarizing film (for a passive set)
- Compatible Systems Service can make TV viewing in full 3D definition and are compatible with normal 2D television.

The frame compatible transmission systems of 3D contents through the television set can be achieved through various techniques that allow to convey the two left and right images into a single frame, as:

- Side-by-side
- top-bottom.

To reduce the bandwidth of transmission some ad-hoc methods are used in which the two images are arranged side by side horizontally (side-by-side: with 1080i resolution) or vertically (top-bottom: with a resolution 720p) constituting a single frame and using the same bandwidth of HD transmission. The methods side-by-side and top-bottom result in a loss (horizontal or vertical) of image quality, because we must carry out sub-sampling / decimation of the source images to be able to squeeze in a format that is one half of a HD framework. Squeeze the left and right images in the format of a single high definition image allows the broadcaster to use the existing infrastructure of production and all distribution infrastructure. In many cases, the set-top-box normally used for HD reception can be utilized.

The DVB Project has recently released specifications for stereoscopic content on TV. The 3DTV Phase 1 specification was published in 2011 for 'frame compatible 'delivery, where the essential requirement was that existing HDTV set-top boxes would allow viewers to watch 3D (with 3D display). This is the most used 3DTV broadcast format today. This DVB standard has therefore turned to Frame compatible systems and provides content strictly 16:9 compressed in H.264 AVC in 3 modes (for the European market) as defined by the DVB-3DTV Committee:

- 720p at 50 Hz, Top-and Bottom-(TAB)
- 720p at 50 Hz, Side-by-Side (SBS)
- 1080i at 25 Hz, Side-by-Side (SBS)

The DVB-3DTV Committee has already issued specifications for the Compatible Frame transmission systems for eight different formats (including 720p/50 or 60, or 60 1080i/50 and 1080p/24) interfacing via HDMI connection 1.4 and the criteria to be adopted to allow proper viewing of stereoscopic image graphics and subtitles. These specifications are used in 3D TV broadcasts already in service by many broadcasters and 3D TVs on the market.

The second stage will define the standard for Service Compatible systems and is expected in late Summer 2012.

Phase 2 was split into a number of parts for manageability. The first part is Phase 2a, which is also called a ‘Service Compatible' mode. The ‘service’ with which it should be compatible is a 1080i/720p HDTV service, so here the HDTV 2D viewer will just see a normal 2D picture at normal HDTV quality, and the viewer with a new 3DTV STB will see a full bandwidth 3D HDTV picture. This is the phase where a new STB will have to be built and the main advantage will result from the improvements in 3D picture quality.

Finally, in autumn 2011, discussion included also a Phase 2b (ITU Level 3), which would be a system built on the original Frame Compatible Phase 1 system. In other words, rather than being an HDTV Service Compatible system, it would be a Phase 1 3DTV Service Compatible system. Commercial requirements for 2b are being evaluated by the DVB project at the moment.

1.2 CONDITIONAL ACCESS SYSTEM, INTERACTIVE SERVICES

1.2.1 CONDITIONAL ACCES SYSTEM

All pay-media operators require a means for ensuring that payment is received in return for the program content they provide. The technical system that achieves this objective is called a conditional-access (CA) system. A conditional access system (CAS) is a system that is designed to allow access to scrambled broadcast services or programs only to authorized users.

It is important that the CA system supports a wide range of charging and payment schemes. These include:

- Subscription (pre-payment for a time period of viewing);
- Pay-Per-View (payment for a programme or group of programmes);
- Impulse Pay-Per-View (payment for a programme or group of programmes without advance notice).

Pay-Per-View (PPV) and Impulse Pay-Per-View (IPPV) often require the provision of a return path from the viewer to the CA system operator: in many systems this is implemented using a telephone connection and a modem built into the IRD.

A generic conditional access system works as follows: the Transport Stream produced by the broadcaster is undergoing the operation of scrambling, using the system DVB standard (DVB Common Scrambling System). The key (control word) used for scrambling is sent to the decoder smart card using encrypted messages called ECM. Each key is specific for a part of streams multiplexed in the Transport Stream. The smart card decrypts the ECMs and sends the control word to the descrambler of the decoder only in the case where the smart card contains the authorization to access the programs decodable by the one control word. Such authorization must have been previously sent to the SC via encrypted messages called EMMs.

The CAS is normally composed by three main components:

- the system for encryption of the service (scrambling),
- the system for the encryption of the "keys"
- subscriber management system (SMS).

The "key" is a string of bits used to control the descrambling process in the decoder. The keys are needed to identify the network to which the subscriber is authorized to access the services of that network and the specific control information to enable the descrambling process.

The ECM (Entitlement Control Messages) are messages that contain the keys for decrypting data streams and are transmitted in an encrypted Transport Stream. Such keys are transmitted along with the programs in a continuous way since, for safety reasons, the decryption keys are regularly changed.

The Entitlement Management Messages (EMM) are used to assign access rights to certain services to the final users. The EMMs are transmitted within the transport stream in a non-continuous mode as in the case of ECM, and contain data about users and their status in terms of access rights. The control words transmitted via EMMs (which can be sent to individual users to groups of them) enable a particular decoder to decrypt the ECMs and then obtain the keys which enable the reception of certain programs.

The Subscriber Authorization System (SAS) is primarily responsible for sending out the over air entitlement messages and for validating security devices. The SAS needs a unique serial number (address) for each IRD security device but should not need access to commercially sensitive information such as the names and addresses of subscribers.

The Subscriber Management System (SMS) is part of the conditional access system and performs the management of customer data, services and programs in addition to requiring the generation of EMMs. The SMS is primarily responsible for sending out bills and receiving payments from viewers. It does not need to, and should not, be specific to a particular CA system. The SMS necessarily holds commercially-sensitive information such as the database of subscribers names and addresses and their entitlement status.

In the eventuality that a customer ceases to pay a subscription the SMS disables, through an appropriate EMM, the decoder to decrypt the programmes which were included in that customer subscription. The Subscriber Authorization System (SAS) generates the EMM following requests by the SMS system.

To access the channels or bouquets proposed by the operators, the customer has possibilities:

- If the customer receiver has the required embedded conditional access systems, then it is sufficient to insert the smart card in the receiver.
- If the receiver does not have the embedded conditional access system required but does have a slot for PCMCIA modules then the customer needs to get a PCMCIA module with the required embedded conditional access system and then insert it in the receiver along with the smart card.

The European DVB Project has designed a Common Interface for use between the Integrated Receiver Decoder (IRD) and the CA system. The Common Interface allows broadcasters to use CA modules which contain solutions from different suppliers, thus increasing their choice and antipiracy options. The IRD contains only those elements that are needed to receive clear broadcasts. The CA system is contained in a low-priced, proprietary module which communicates with the IRD via the Common Interface. No secret conditional access data passes across the interface.

CI Plus is a technical specification that adds additional security and features to the proven DVB Common Interface Standard that will allow CI Plus compatible consumer electronic devices, such as Integrated Digital Televisions and Set Top Boxes, access to a wide range of Pay TV Services via plug-in CI Plus Modules wherever the CI Plus Technology is supported by the local Pay TV Provider.

The DVB Project has given its backing to two CA approaches for the transmission of digital television: namely *SimulCrypt* and *Multi-Crypt*.

SimulCrypt uses multiple set-top boxes, each using a different CA system, to authorize the programs. The different ECMs and EMMs required by each CA system are transmitted simultaneously. Each STB recognizes and uses the appropriate ECM and EMM needed for authorization. Therefore, each service is transmitted with the entitlement messages for a number of different proprietary systems, so that decoders using different conditional access systems (in different geographic areas) can decode the service. SimulCrypt requires a common framework for signalling the different Entitlement Message streams. Access to the system is controlled by the system operators.

MultiCrypt uses common receiver/decoder elements which could be built into television sets. The Common Conditional Access Interface can be used to implement MultiCrypt. Conditional access modules from different system operators can be plugged into different slots in the common receiver/decoder, using the common interface.

1.2.2 Interactive services

In DTV broadcasting, a new interesting feature is the interactivity, that is the chance to deliver multimedia applications interacting with the user and giving a consistent added value to DTV services. Interactive television provides additional features for television programmes, ranging from alternative sound tracks and camera views to additional information on the participants. Alternatively, items that have nothing to do with TV programmes can be transmitted alongside the programmes, like video games. Interactive television may provide administrations with the means to render Information society services attainable to all citizens.

Interactive television requires a stack of software components to be added to the basic digital television receiver, called an applications programme interface (API), similar to that in a computer. The API, also known as middleware, is the underlying technical facility for features such as the Electronic Programme Guide, Personal Video Recorders (PVRs) and any interactive television service

To implement interactivity in a correct way, several standards are available

1.2.3 MHP

MHP, or the Multimedia Home Platform, is the collective name for a compatible set of middleware specifications developed by the DVB Project. MHP was designed to work across all DVB transmission technologies. The use of an open standard for interactive TV middleware means that receiver manufacturers can target multiple markets rather than developing products to the specification of a particular broadcaster. Equally applications based on MHP can be developed by multiple service providers, enabling a horizontal market in that area. Three versions of MHP have now been published; each adding new features useful in a broadband world. In all versions, a broadcast-only profile can be supported, although most modern deployments include broadband connectivity.

Each MHP version is designed to address specific market needs:

- MHP 1.0 is for unidirectional interactivity, mainly aimed at horizontal DVB-T markets, with limited use of a return channel
- MHP 1.1 is for bidirectional interactivity
- MHP 1.2 is for bidirectional interactivity including video streaming. MHP 1.2 also includes features that allow further customization of the end-user experience by Pay TV operators.

At its simplest, MHP can be described as a set of instructions that tells the operating system on a digital TV receiver how to deal with an interactive TV application it has received. MHP also defines the form in which the applications are delivered at the receiver, including the service information that signals that interactive applications are present in the transport stream.

MHP has a core based around a Java virtual machine. MHP does not compete with the different HTML or MHEG flavours, since in MHP, each of these declarative content engines is an just another MHP application. If new requirements emerge, updating and deploying an MHP application is much simpler and cheaper than re-defining and updating native HTML or MHEG engines particularly if there are many different native engines in the market. MHP provides a sophisticated application deployment engine for operators, giving the power and robustness of downloadable applications, while maintaining a zero-administration television experience for the end-users. The end result is an easy way to deploy sophisticated television services that can be enjoyed by all viewers.

The Multimedia Home Platform (MHP) defines a generic interface between interactive digital applications and the terminals on which those applications execute. This interface de-couples different provider's applications from the specific hardware and software details of different MHP terminal implementations. It enables digital content providers to address all types of terminals ranging from low-end to high-end set top boxes, integrated digital TV sets and multimedia PCs. The MHP extends the existing, successful DVB open standards for broadcast and interactive services in all transmission networks including satellite, cable, terrestrial and microwave systems.

1.2.4 MHEG-5

MHEG-5 is the language used for digital text and interactive applications for DTT platform. If a channel is listed as MHEG, this means it has a significant MHEG layer. "Significant" means there is a digital text service, programme-related interactivity or dynamically updating information available during some or all broadcast hours.

MHEG-5 has its own simple object orientated programming language which enables:

- control over the presentation of content made up from audio, video, text and still graphics objects
- user interaction with the application
- support of real time video and audio presentation

The UK Profile defines the complete environment from applications, playout, signalling and the receiver API or middleware

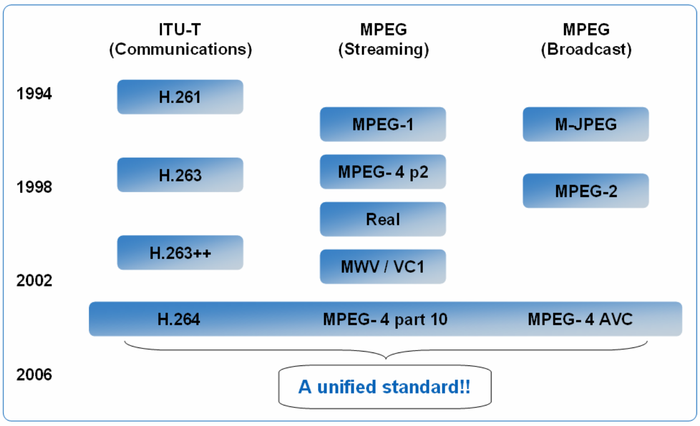
1.3 TRANSMISSION SPECTRUM EFFICIENCY: COMPRESSION, TRANSMISSION STANDARD, STATISTICAL MULTIPLEXING, SFN

1.3.1 COMPRESSION

1.3.1.1 MPEG-4

MPEG-1 and MPEG-2 were limited and could not fulfil the new needs of emerging multimedia applications, such as hyper-linking, interaction and natural and synthetic data integration. MPEG-4 is the answer to the requirements coming from the new ways in which audiovisual information is nowadays produced, delivered and consumed.

H.264/MPEG-4 Advanced Video Coding standard (H.264/AVC for brevity), which is also known as H.264/MPEG-4 Part 10. H.264/AVC in turn compresses video significantly more efficiently than MPEG-4 MPEG-4 AVC/H.264 is at least twice as efficient in compression as MPEG-2.



The compression algorithm used in MPEG-4 AVC/H.264 is basically the same as that used in MPEG-2. They use inter-frame prediction, quantization, entropy coding, etc. But in MPEG-4 AVC/H.264, these tools have been improved significantly and new tools, such as arithmetic coding and filters, have been added. Further, by using various modes appropriate for the characteristics of the images, MPEG-4 AVC/H.264 achieves compression efficiency far better than that of MPEG-2.

To reach this target, MPEG-4 follows an object-based representation approach where an audiovisual scene is coded as a composition of objects, natural as well as synthetic, providing the first powerful hybrid playground.

The advantages of coding audio-visual objects can be summarized as follows:

- It allows interaction with the content. At the client side, users can be given the possibility to access, manipulate, or activate specific parts of the content.
- It improves reusability and coding of the content. At the content creation side, authors can easily organize and manipulate individual components and reuse existing material. Moreover, each type of content can be coded using the most effective algorithms. Artifacts due to joint coding of heterogeneous objects (e.g., graphics overlaid on natural video) disappear.
- It allows content-based scalability. At various stages in the authoring/delivery/consumption process, content can be ignored or adapted to match bandwidth, complexity, or price requirements.

In order to be able to use these audio-visual objects in a presentation, additional information needs to be transmitted to the client terminals. The individual audio-visual objects are only a part of the presentation structure that an author wants delivered to the consumers.

The objective of MPEG-4 is thus to provide an audiovisual representation standard supporting new ways of communication, access, and interaction with digital audiovisual data, and offering a common technical solution to various service paradigms – telecommunications, broadcast, and interactive – between which the borders are disappearing. MPEG-4 shall supply an answer to the emerging needs of application fields such as video on the Internet, multimedia broadcasting, content-based audiovisual database access, games, audiovisual home editing, advanced audiovisual communications, notably over mobile networks, tele-shopping, and remote monitoring and control.

MPEG-4 Systems requirements may be categorized into two groups:

- **Traditional MPEG Systems Requirements**: The core requirements for the development of the systems specifications in MPEG-1 and MPEG-2 were to enable the transport of coded audio, video and user-defined private data, and to incorporate timing mechanisms to facilitate synchronous decoding and presentation of these data at the client side. These requirements also constitute a part of the fundamental requirements set for MPEG-4 Systems. The evolution of the traditional
- **Specific MPEG-4 Systems Requirements**: The requirements in this set, most notably, the notions of *audio-visual objects* and *scene description*, represent the ideas central to MPEG-4 and are completely new in MPEG Systems. The core competencies needed to fulfil these

requirements were not present at the beginning of the activity but were acquired during the standards development process.

To understand the complexity of the new compression standard, compared to MPEG-2, MPEG-4 AVC (H.264) requires 8 times the processing power for encoding and 3 times the processing power for decoding. So developing encoder and decoder technology is not trivial, especially if performance is a concern.

1.3.1.2 HEVC

A new video compression standard, known as High Efficiency Video Coding (HEVC), is currently being jointly developed by ISO/IEC MPEG and ITU-T VCEG, the same two standardization bodies whose previous collaboration resulted in both MPEG-2 and H.264/AVC. The goal is to achieve a factor of two improvement in compression efficiency compared to the H.264/AVC, the best performing of the current generation of standards. A first draft of the standard has been drafted with the name H.265.

The HEVC standard is scheduled to reach Committee Draft stage in February 2012 and to be published from Final Draft International Standard in January 2013. The next table shows the forecast timetable relative to this new coding standard:

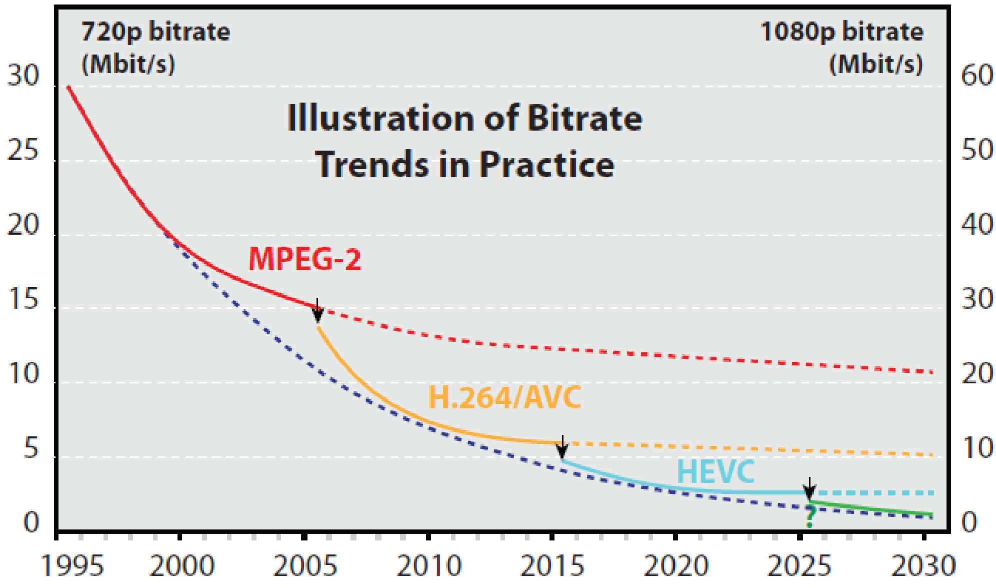
Timescales for Video Coding Standards

	Standard Published	Added to DVB	First Broadcast Services Launched
MPEG-2	1995	1996	1997
H.264/AVC	2003	2004	2005
HEVC	2013	2014	2015

Source: DVB

In the real world, improvements do not follow a smooth curve, as legacy issues prevent overly frequent changes of algorithm. This is illustrated in the graph, which shows MPEG-2, H.264/AVC, HEVC and the possibility of a future standard around 2025.

The graph shows shows the development of HEVC performances in rime applied to two HD format videos. In particular, HEVC should get an improvement of 2 in the compression ratio compared to H.264/AVC by 2020. By achieving that HEVC should be capable of requiring about 2/3 Mbit/s for a HDTV 720p and about 5 Mbits/s for HDTV 1080p.



Source: DVB

1.3.2 TRANSMISSION TECHNIQUES

1.3.2.1 DVB-T2

The Digital Video Broadcasting (DVB) is an industrial consortium comprising some 250 broadcasters, manufacturers, network operators and national regulatory authorities. It produces open technical standards for television broadcasting and it has defined the DVB-T2 for the diffusion of new generation terrestrial. DVB-T2 is innovative since it is the improvement and upgrading of the existing standard DVB-T. In 2008 the DVB committee presented DVB-T2 specification to ETSI (European Telecommunications Standards Institute) which gave the final approval of DVB-T2 in September 7, 2009 (ETSI EN 302 755 V1.1.1 (2009-09)).

From a strictly technical point of view the DVB-T2 standard represents a technological evolution of the DVB-T standard. Like the DVB-T standard, the DVB-T2 specification uses OFDM (Orthogonal Frequency Division Multiplex) modulation. The availability of a large number of modes allows for the same level of flexibility to suit the specific area of application as with the DVB-T standard. However, the addition of the 256 QAM mode in the DVB-T2 specification allows for the ability to increase the number of bits carried per data cell and benefit from improved FEC (forward error correction) which gives a major capacity boost. The main DVB-T2 technical improvements are detailed as follows:

- possibility of use of codes correction of errors LPDC (Low Density Parity Check) code followed by the BCH (DVB-T foresaw the use of Reed-Solomon codes followed by convolutional codes);

- possibility of extending some technical parameters of the OFDM modulation scheme (eg, use of additional layers in the modulation scheme as the 256-QAM, extension of the number of carriers such as the 16K and the 32K, etc.).;
- possibility of adopting certain innovations such as time-frequency slicing, etc.

The following table provides a summary of available modes in DVB-T and DVB-T2:

Comparison of available modes in DVB-T and DVB-T2

	DVB-T	DVB-T2
FEC	Convolutional Coding + Reed Solomon 1/2, 2/3, 3/4, 5/6, 7/8	LPDC + BCH 1/2, **3/5**, 2/3, 3/4, **4/5**, 5/6
Modes	QPSK, 16QAM, 64QAM	QPSK, 16QAM, 64QAM, **256QAM**
Guard Interval	1/4, 1/8, 1/16, 1/32	1/4, **19/256**, 1/8, **19/128**, 1/16, 1/32, **1/128**
FFT size	2k, 8k	**1k**, 2k, **4k**, 8k, **16k**, **32k**
Scattered Pilots	8% of total	**1%**, **2%**, **4%**, 8% of total
Continual Pilots	2.6% of total	**0.35%** of total

Source: DVB Project

These new features provide greater efficiency to the performance of the digital terrestrial platform, compared to the first-generation systems (DVB-T), which allows an increase spectral efficiency, or more bits / s / Hz. In other words, for the same band, more television channels can be transmitted or the same number of television channels, but in higher quality (for the same transmission parameters of all the increment in terms of bit rate and therefore the number of channels is equal to about 35/40%).

As a result, DVB-T2 can offer a much higher data rate than DVB-T or a much more robust signal. For comparison, the following table show the maximum data rate at a fixed C/N ratio and the required C/N ratio at a fixed (useful) data rate:

	DVB-T	DVB-T2
Typical data rate (UK)	24 Mbit/s	**40.0 Mbit/s**
Max. data rate (@20 dB C/N)	29 Mbit/s	**47.8 Mbit/s**
Required C/N ratio (@22 Mbit/s)	16.7 dB	**8.9 dB**

Similar to the DVB-T standard, the DVB-T2 specification provides operators with significant flexibility to launch new digital television services on the terrestrial platform. The new services that could be offered on the DTT platform will be based the development of new technologies in combination with the demands of the market and could, for example, include HDTV, SDTV, 3D TV, video-on-demand, etc.

Because of the capacity improvements compared with the DVB-T standard, operators can consider offering either more standard-definition services or to launch bit-rate demanding services such as high-definition services. For example, assuming that a capacity of nearly 40 Mbit/s is possible in a given DVB-T2 multiplex, it could be possible to provide between 4-6 high-definition services or between 15-20 standard-definition services. In either scenario, it will result in lower transmission costs for each service.

DVB-T2 gives the possibility to use 16k or 32k carrier modes. Due to the longer symbol lengths of the 16k and 32k modes, with the same fraction of guard interval (1/32, 1/8, 1/4, ...) the guard time expressed in μs increases. This can be used to increase the possible SFN size, by keeping the guard interval as fraction of the symbol length unchanged, or it can be used to increase the capacity, by changing the guard interval as fraction of the symbol length in such a way that the guard time expressed in μs is kept unchanged. By carefully choosing the parameters, also am combination of both is possible: a (more moderate) increase of the SFN-size combined with an (more moderate) increase of capacity.

In order to allow for the launch of DVB-T2, broadcast network operators will need to roll out a DVB-T2 transmission network. However, the cost of the network roll out is reduced significantly since broadcast network operators can use their existing transmitter infrastructure including sites, transmitters, masts, and antennas. It will only be necessary to acquire a DVB-T2 modulator to replace the DVB-T unit. The difference in price between DVB-T and DVB-T2 equipment reduced significantly and it is now in 10/20%.

Because DVB-T2 targets fixed roof top and portable antennas, as does DVB-T in most countries, it is unlikely that new transmission sites will be necessary. Given that planning parameters do not need to change between DVB-T and DVB-T2, it can be assumed that coverage areas will remain the same unless the broadcaster wishes a change. Consequently, the compatibility guaranteed by the standard DVB-T2 are the following:

- with current transmitter sites;
- present with receiving facilities;
- the planning GE06.

The new DVB-T2 decoders are normally capable to receive also the DVB-T signals, but the opposite thing is not possible because of differences in hardware due to the new system of decoding and of the differences of the demodulator. A multitude of DVB-T2 set-top boxes and integrated TV receivers are now available and prices have already dropped considerably. The price difference between comparable DVB-T and T2 integrated TV sets is already almost negligible.

1.3.2.2 Statistical Multiplexing

Statistical multiplexing can be utilized in order to save the bandwidth or increase the quality of picture. Normally any given service is allocated a constant bit rate. This is called Constant Bit Rate

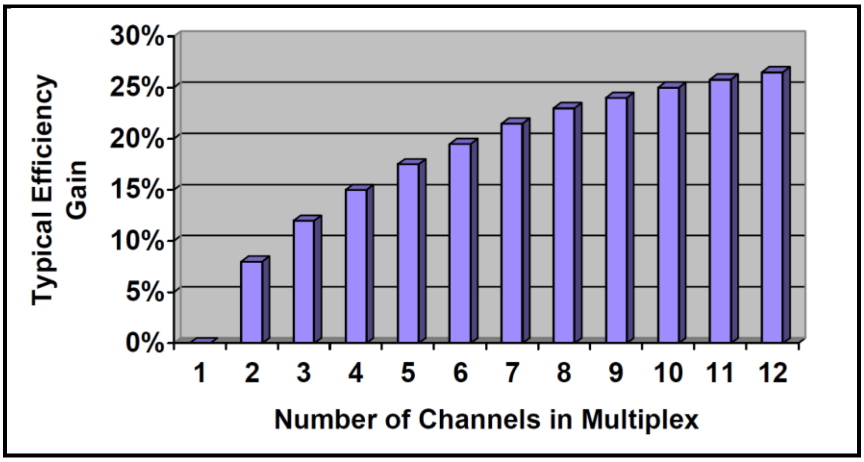
(CBR) encoding. This technique is quite inefficient because this constant bandwidth must be set in such a way that the quality of the service will not suffer even in the most critical and demanding moments. On average there is no need to use the whole allocated bandwidth because video has a lot of redundancy and, for example, still scenes need less capacity for transfer. To optimize the multiplex bandwidth allocation Variable Bit Rate (VBR) encoding can be used. In this process every service gets bandwidth according to encoding complexity at any given time. On average there is still some fixed bandwidth or multiplex capacity available but at a given moment one individual service can get much more bandwidth to encode and transfer complex scenes. There are two basic approaches for joint rate control, the look-ahead approach and the feedback approach.

Statistical multiplexing is based on the assumption that it is fairly unlikely that all programs transmitted by the same multiplex will consist of critical scene material at precisely the same time. Therefore it is conceivable that an intelligent multiplexer will drive the output data rate of the encoders so that the one whose program momentarily makes the highest demands on the MPEG coding process is instantaneously allowed the highest output data rate. This assumption is even truer when the number of independent items of picture information (program data streams) that are added to a transport data stream in the multiplexer becomes larger.

The exact efficiency gain is dependent on both the nature of the video content and the details of the implementation, but gains can be typically expected to asymptotically approach a value between about 25 and 30% for large numbers of channels. The graph in Figure 1 below is indicative of the typical benefits that can be expected, based on statements from encoder manufacturers and the author's own experience

The figure shown below provides a view of the efficiency of a statistical multiplex versus the number of independent television programmes. It is assumed that the content in each channel is uncorrelated and that each has similar bit-rate targets. There may be a very slight reduction in the benefit if unequal priority is used to give higher quality thresholds for some services than others.

Source: Review of DTT HD Capacity Issues An Independent Report from ZetaCast Ltd Commissioned by Ofcom.



From this figure in the case of 10/12 independent television channels broadcast via the same Mux (this could be the case for SD independent channels, DVB-T2, MPEG-2) a gain equal to about 25% could be achieved through the usage of a statistical multiplex.

From this figure in the case of 5/6 independent HD television channels broadcast via the same Mux (this could be the case for HD channels broadcast via DVB-T2, MPEG-4. Hence a gain equal to about 15% could be achieved through the usage of a statistical multiplex.

Furthermore, statistically multiplexing a mix of HDTV and SDTV content is also possible, but this is likely to give significantly less benefit, as a demand peak on the HDTV channel will require several SDTV channels to reduce bit-rate to compensate. A particular case to avoid is multiplexing an HD and an SD version of the same programme on a single multiplex, as the peaks of demand will coincide.

The next table summarizes the results in terms of band efficiency which can be obtained with the combination of the above illustrated techniques:

	Mpeg-2 Dvb-T	H.264/AVC Dvb-T2	H.264/AVC Dvb-T2 stat. mux	HEVC Dvb-T2 stat. mux
SD	6-8	10-14	12-18	+20
HD	1-2	4-6	5-7	+10

1.3.3 Single Frequency Network (SFN)

Introduction

With SFN all transmitters utilize the same frequency and exploit the property that if the SFN is properly designed, the received signal components do not produce ISI (Inter-Symbol Interference) but constructively add in the receiver. In this case SFN allows for a sharp increase of the spectrum efficiency, since the frequency reuse factor is equal to one in case of SFN (compared to a value of at least three for MFN).

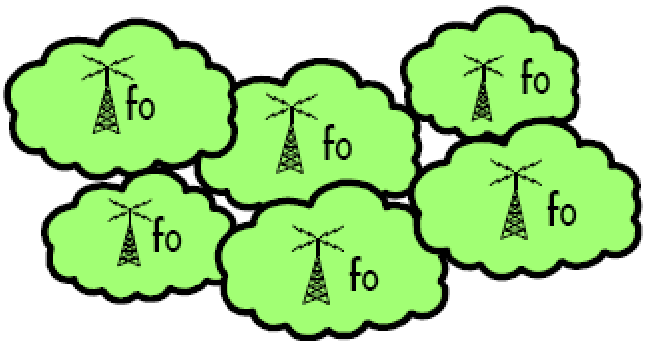


Fig. xx: Example of SFN Network

Multiple Single Frequency (k-SFN)

The network is composed by several SFNs, each one operating each a portion of the global service area. Adjacent SFNs use different frequencies. The network can be described as a MFN network where SFNs composed of several transmitters replaces single transmitters as in the standard MFN networks. This architecture can be advantageously applied when: a) the nature of the territory makes larger SFNs very difficult to build and manage; b) for regional networks, i.e. when the signals transmitted over adjacent areas are partially or totally different.

Multi Frequency (MFN)

As in analogue TV, each transmitter irradiate an independent programme with a different frequency (with respect to adjacent transmitters). Several frequencies are needed to cover large areas; the number of frequencies needed to provide the broadcasting of a single programme corresponds to the frequency reuse factor; it depends on the characteristics of the territory (flat land requires higher reuse factors), the desired reception quality, and on the frequency band of operation. MFNs do not require signal synchronisation among the transmitters. The advantage of the MFN approach is that a significant part of the existing analogue network infrastructure may be re-used, which has obvious cost-saving implications for the network operators and broadcasters but also provides benefits for the viewers (e.g. the possibility to re-use their existing receiving antenna and feeder system).

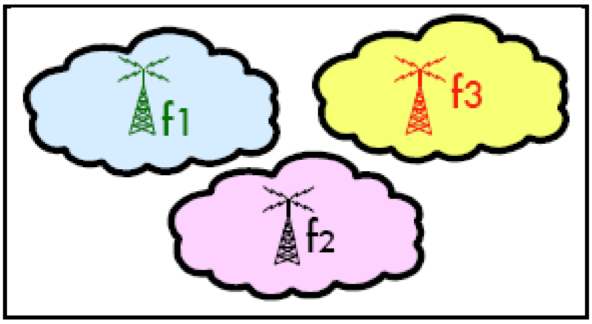


Fig. xx: Example of MFN Network

1.3.4 Generalities on optimisation of radio systems

Given a system characterised by certain variables, optimisation means to find the set of values of variables which yields the minimum (or maximum) of a function which represents the degree of desirability.

The general definition of an optimisation problem include:

- a set of *N* variables χ_i, *i=1,2,…,N*, each with a set of Nr_i ranges of allowed values $[l_{ij}\text{-}h_{ij}]$, $j=1,2,..,Nr_i$;
- a set of further constraints on the simultaneous values of the variables (i.e. some values of a variable, though allowed in principle, could be incompatible with certain values of other variables), identifying the region of the *N*-dimensional space where the system is allowed to operate;
- a cost-function $F(\chi_1,\chi_2,\ldots,\chi_N)$, generally given as the weighted sum of different functions $f_i(\chi_1,\chi_2,\ldots,\chi_N)$, characterising different "qualities" of the system.

To solve a problem of optimisation means to find the vector $[\chi_1,\chi_2,\ldots,\chi_N]$ that yields the minimum value of $F(\chi_1,\chi_2,\ldots,\chi_N)$.

For many practical systems, an analytical solution is not viable, and the problem must be solved by means of numerical computation.

The ever increasing computational power available today allows to solve even complex optimisation problem finding the absolute minimum of the cost function by means of exhaustive computation, i.e. the absolute minimum if found comparing all possible values of *F*.

For increasing complexity of the system (higher values of N and possible values of each χ_i), exhaustive computation would require unacceptable computation time. In this case, optimisation is usually realised adopting *heuristic algorithms*, which search for a sub-optimal solutions.

Such algorithms (from simple *tabu search* to *simulated annealing*) explore the region of possible solutions trying to improve the best solution find so far. The parameters of the algorithm should be carefully selected according to the nature and values of the problems: a trade-off must be found to avoid on one hand the risk of being trapped in a local minimum, on the other hand the risk of not being able to find a better minimum close to the present solution.

The basic "philosophy" of each of such algorithms, i.e. the way it proceeds in the search for a better solution, defines the algorithm; but the user must set the value of the parameters driving the process of the search according to the nature of the specific optimisation problem. There no one-fit-all solution: a set of parameters that works very well for a problem can perform badly in case of a problem apparently similar. That is to say that optimisation by means of heuristic procedure can be done only if the nature of the algorithm is well known.

Heuristic algorithm are frequently employed in case of frequency plans over large areas, such as Geneva 2006 broadcasting plan. In Italy, due to the large number of transmitters, national frequency plans for broadcasting have been obtained in this way.

In many cases, it is convenient to proceed by successive steps of optimisation: for instance, perform first local optimisation in small areas, in order to fix the values of some variables and thus reduce the complexity of the global task of optimisation.

1.3.5 Examples of radio planning optimisation

In practical cases, optimisation is effectively performed on a sub-set of all variables characterising a radio system. For instance, the number and locations of transmitters may be fixed and the problem of optimisation concerns the allocation of frequency to each of them.

The definition of the cost function and the weight of each factor is a crucial issue: their formulation must be performed in order to correctly reflect the scopes of the planners, including the appropriate ranking of relevance of each component. The definition of the cost function is completely case-specific. Typically the cost function increases with the degradation below the desired threshold of the signal quality received by a part of population, but how this is formulated and weighted is the task of the planners.

The following list contains some examples of the most frequent optimisation problems encountered in the planning of radio systems.

- given a number of transmitters (mutually interfering) and a set of frequencies, allocate the frequencies in order to maximise the population able to receive with good quality;
- given a set of possible transmitters of a network, select a fixed number N in order to maximise the population served with good quality, with or without interference;
- given a set of transmitters (mutually interfering) and a set of assigned frequencies, find the configuration of ERP values which maximises the population served with good quality;

Cost-functions are usually based on population served with good quality, number of channels received, as well as economic factors (such as the number of required transmitters, cost of adequate transmitters or required power levels).

In case of SFN networks, compared to traditional MFN networks, further applications of optimisation can be found in the synchronisation of the transmitters as well as in their selection and design, in order to minimise the population affected by self-interference.

Further optimisation and efficient spectrum usage can be achieved by multiplexing programmes of different broadcasters, operating in the same geographic area, into one multiplex (one SFN network) instead of each broadcaster using its own network with more than half unused capacity of the multiplex. In that way capacity of the multiplexes would be used more efficiently which brings us to the better spectral efficiency in respect to the used (bit/s)/Hz.

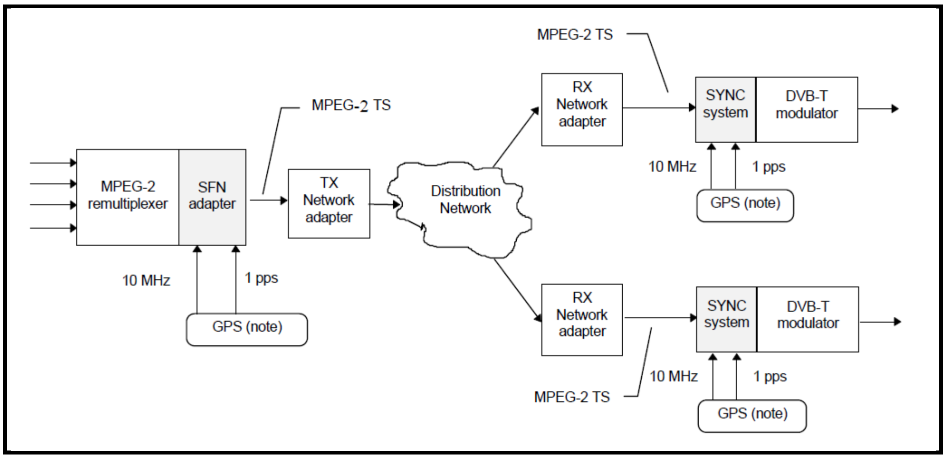
1.3.6 SFN Network Synchronization

A price to pay for frequency and power efficiency is the synchronous operation of all transmitters in a given network. COFDM systems have been designed to take benefit from echoes, as long as they enter the guard interval. This condition requires time synchronization of the various transmitters, since the same symbol has to be emitted at the same instant from several places, whatever the time delay introduced by the distribution network. The needed time accuracy for this is not very high, because of the intrinsic tolerance brought by the guard interval duration, which is often noted GT. However, since the guard interval should be used to make up for the terrestrial channel time delay spread and not to compensate inaccurate network time synchronization, an accuracy of ±1 µs seems a good basis. Achieving synchronism of all transmitters needs specific provisions (see clause 8 on SFN operation). In networks for large area coverage with 8k-mode and guard interval of ¼ (i.e. 224 µs), tolerances of ±5 µs should not cause performance degradation. The requirement of synchronous transmitter operation has significant impact on the distribution of the programme multiplex signal to the transmitters (see sub clause 7.1 on primary distribution).

In irregularly spaced networks the self-interference may be minimized by a specific time offset of certain transmitters The synchronous operation of all transmitters in an SFN does not preclude altering any part of the modulation signal at any transmitter within the SFN, e.g. to install a local service inside the network. The difference in the modulation signal causes the transmitter in question to turn to an interferer affecting the surrounding transmitters for the duration of signal difference.

The maximum time spread introduced by the distribution network is the difference between the time needed by the signal to go from the MUX through the network to the nearest transmission site on the one hand and the time needed by the same signal to go from the same MUX through other branches of the network to the furthest site on the other hand. It strongly depends on the chosen technology for this network; the longest time spread are probably reached in hybrid networks, in which some transmitters are fed using one technology (e.g. fibre optics) whilst other sites are fed using another technology (e.g. satellite links). However, it is very unlikely that this transit time difference would exceed one second. In an SFN network, each modulator is fed from the multiplexer through a distribution network, which introduces a time delay that varies from one transmitting site to the other. Consequently, no time reference can be given to the transmitters from the multiplexer. There is a need for an external absolute time provider, able to offer to each site a time value with an accuracy better than 1 µs.

GPS seems to be an excellent candidate for that purpose. Suitable GPS receivers provide both a frequency reference (10 MHz) and a phase reference of absolute time.



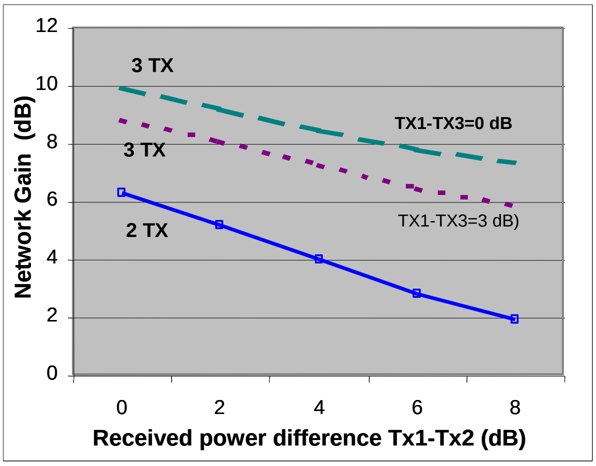
The first step in order to achieve synchronization of the SFN Network is to dispose of a common time reference source common among the head-end and the various SFN transmitters. The time reference source utilized is the GPS clock (1 pps and 10 MHz) and as a consequence all transmitters and the head-end will include a GPS receiver. The second step is that at the input of the Network (head-end) it is needed to insert a “time-stamp” which can be recognized by each network output (transmitter). The chosen time-stamp is the beginning of a Megaframe (by definition a Megaframe contains a predefined, fixed number of MPEG packets). The Megaframe start-up is individuated by indicating the after how many packets from a certain event such start-up is positioned. The event is the emission of a special packet called MIP which is inserted periodically by the SFN adapter. In a particular field of the MIP (Pointer) it is indicated the distance in terms of packets which separates the MIP from the next Megaframe start-up. In such a way an SFN transmitter can operate the inverse procedure: it extracts the field Pointer and utilizes such value to count the following packets until it individuates the Megafrane start-up. Then an allignement procedure is operated in order to estimate the Network Transmission delay at each transmitter and synchronize the entire SFN Network.

1.3.7 SFN Network Gain

It is known that if the SFN is properly designed, the received signal components do not produce ISI (Inter-Symbol Interference) but constructively add in the receiver . In fact the OFDM receiver synchronizes its symbol time reference (t_k=kT_s+t_0) to a given transmitter chosen according to a predefined strategy (e.g first path, maximum power, maximum signal-to-noise ratio, etc.). All the signal components received with a delay t_i such that t_i-t_0<T_g give a constructive contribution to the useful signal energy which results in a SFN performance improvement when compared to traditional MultiFrequency Networks (MFN) where each transmitter uses a different frequency. This effect, usually referred to as “SFN network gain”, can be obtained if the SFN transmitters are not too far apart to avoid that the delays of the received contributions exceed the guard interval.

We define the network gain, in a single pixel of a SFN, as the difference between the average power required by a single isolated transmitter (belonging to a MFN) and the average power required by the same transmitter operating in a SFN to obtain a fixed coverage probability. The network gain of a SFN with respect to a MFN derives from two factors: 1) all signals received within the guard interval give a positive contribution to the received signal energy (power sum effect); the standard deviation of the combined received field is smaller than the standard deviation of a single signal, thus decreasing the required power margin required to compensate for the shadowing effect.

Fig.2 provides the network gain in a single pixel, obtained using in the case of a SFN with two and three transmitters (called TX1, TX2, TX3) varying the power difference between TX1 and TX3.



1.3.8 Transmission delay optimization for SFN Networks

The following material provides some insight of optimization of the transmission delays in the simple case of considering two transmitters. In fact for SFN networks, further optimization can be performed on the synchronisation (transmitters delay optimization) of the transmitters to minimize the population affected by self-interference

The following picture shows the relative delay Δt between rays arriving from two synchronized transmitters which are located at a distance of 100 Km . The lower Δt, the better the two signals combine for SFN. For OFDM, the maximum distance is imposed by the condition Δt < τg (guard interval)

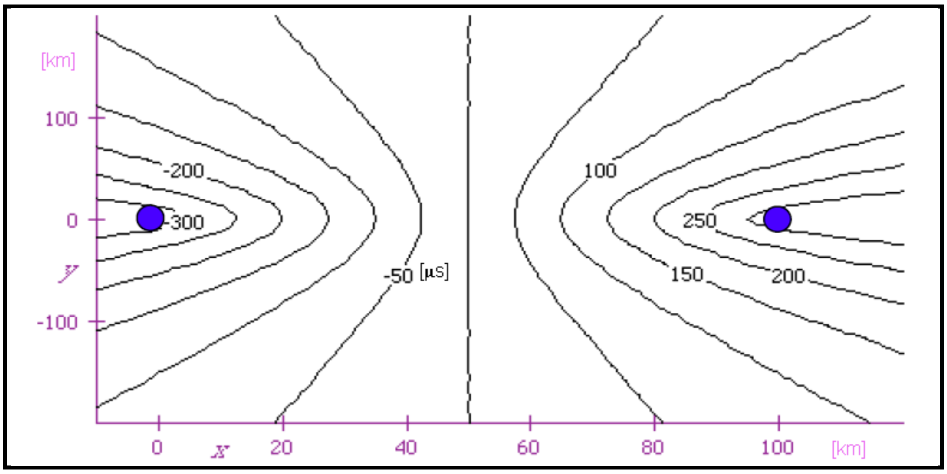


Fig 1. Rays from two transmitters located at 100 Km distance

If there is a densely populated area (e.g. a major city shown by an orange circle), as in the next figure, close to one transmitter, there might be delay problems. The planner must improve the situation in order to optimize the coverage.

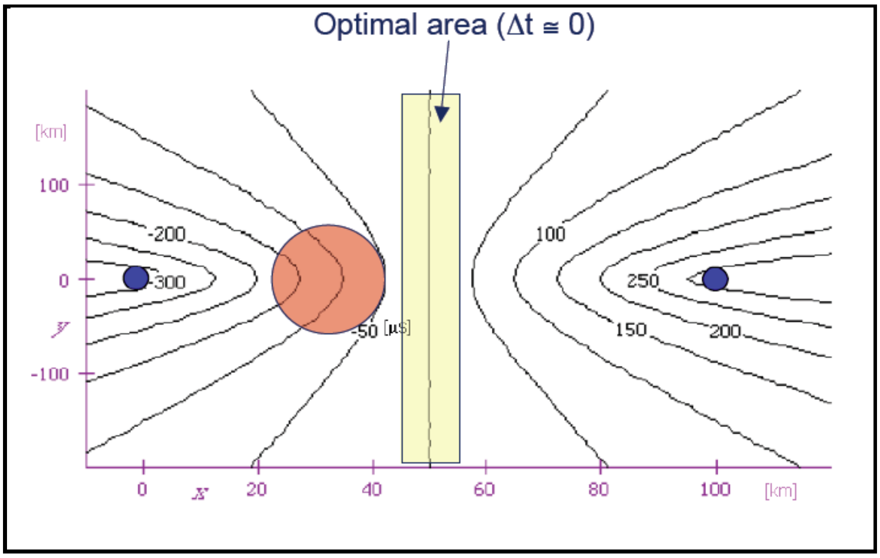
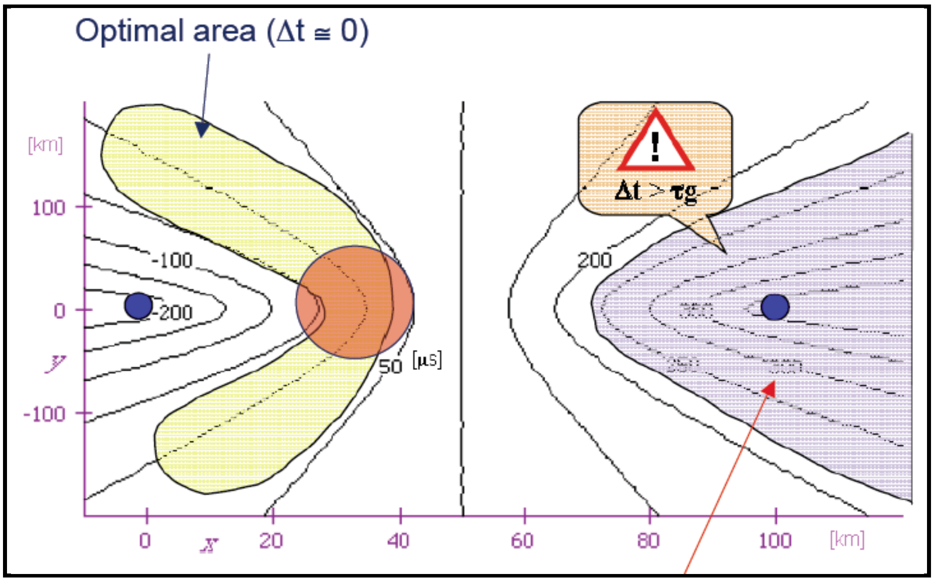


Fig. 2 Rays from two transmitters located at 100 Km distance with a large town to cover (orange circle)

The planner may improve the situation by introducing a delay in one transmitter (transmitter located at x = 0 is delaying its transmission). By doing that the city will fall in the optimal area (Δt ≅ 0) and the coverage will be optimized.



It is important to note that operating in this way in the vicinity of the site, we may have a region with Δt > τg, which could require higher protection ratios.

With many sites/transmitters it is needed the usage of a simulator which shall be able to modify and optimize the single station's delay times to remove self-interference of an SFN Network. SFN delay times optimization should be based on operative research methods as for example the "simulated annealing" algorithm.

1.3.9 Conclusions

With the SFN approach all the transmitters in the network irradiate the same signal synchronously on the same frequency channel. SFN allows for a sharp increase of the spectrum efficiency, since the frequency reuse factor is equal to one in case of SFN (compared to a value of at least three for MFN). In particular, the SFN approach may be favourable for large service areas (however taking account of the limitation of the maximum achievable network size) and where the same frequency is available across such a large area.

Large SFNs are not suitable for the small local broadcasters because the mux stream transmitted from each SFN transmitter must be identical over the whole service area in order to enable signals to be added constructively at the receiver, so for the small local coverage small SFN networks can be used or just single transmitter per targeted service area. It is often necessary to undertake a large scale frequency re-arrangement to free up such frequencies for national SFNs. This may include the need for international frequency coordination.

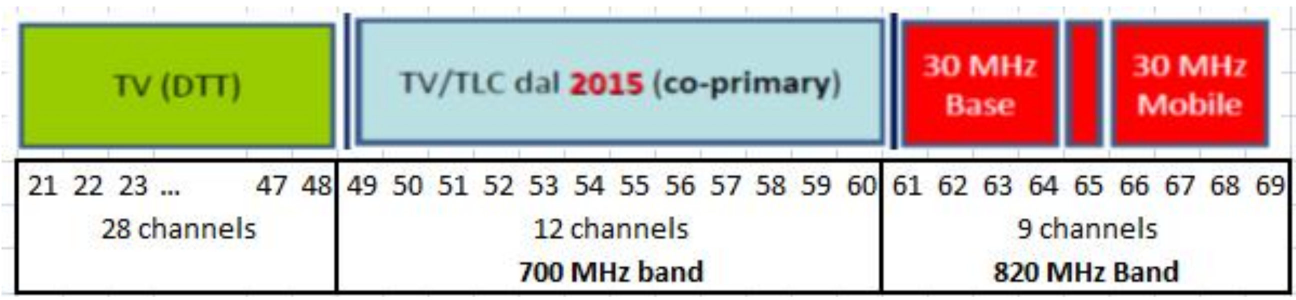
DTT network configuration needs to be optimised with regard to a number of parameters, such as the size of the service area, terrain, population distribution, availability of transmission infrastructure and in particular tied to synchronization of all transmitters in a given SFN network should be performed carefully. COFDM systems have been designed to take benefit from echoes, as long as they enter the guard interval. This condition requires time synchronization of the various transmitters, since the same symbol has to be emitted at the same instant from several places, whatever the time delay introduced by the distribution network. Signals from different transmitters add constructively at the receiver as far as the mutual delay is within the time length of the guard interval. Otherwise, a specific kind of self-interference arises. It follows that, in principle, a longer guard interval (*Tg*) allows to build larger SFNs.

The decision to implement SFN networks is depending from the particular situation for each country and hence such decision should be left to each competent authorities in each country together with broadcasters and network operators, depending on their own national characteristics (such as topology and geography) and their own national objectives fully respecting the provisions of GE’06 Agreement and ITU Radio regulations. Nevertheless it is proven that SFN networks enables more efficient spectrum usage, especially taking into account GE’06 plan which consists of allotments (geographic area with allocated frequency) and corresponding assignments, SFN networks in most cases provide optimal solution.

1.4 DIGITAL DIVIDEND

The digital dividend is derived by the ability of digital compression systems to allow the transmission of up to 8 standard digital TV channels in the spectrum previously used by one analogue TV channel, using the most advanced technologies. The gain will be even more substantive if more advanced standards are being introduced (such as DVB-T2 for infrastructure and MPEG-4 for compression). The switchover from analogue to digital terrestrial TV, to be completed in Europe by the end of 2012, will free up a very large amount of radio spectrum. This ‘digital dividend’ will provide a unique opportunity to meet the huge demand for new wireless communications services, allow broadcasters to significantly expand their services and at the same time provide spectrum for social and economic uses. Applications in this latter category will include broadband applications which can help overcome the ‘digital divide’: ensuring equitable access to new information and communication technologies.

The spectrum used to broadcast analogue TV, located between 200 MHz and 1 GHz, has very attractive propagation characteristics, and offers an optimal balance between transmission capacity and distance coverage. Commonly, we refer to digital dividend for the 790-862 MHz band (the ‘800 MHz band’, CH 61 - 69), and to second digital dividend for the 694-790 MHz band (the '700 MHz band', 694-790 MHz or CH 49 to Ch 60). The following figure shows such digital dividend spectrum assignments:



Availability of radio spectrum is a clear enabler for economic and social growth. This illustrates why it is vital that the next opportunity to provide the much needed wireless bandwidth, the 'digital dividend', is managed as efficiently and effectively as possible to ensure the maximum benefit for all.

If the digital dividend is managed as efficiently and effectively as possible, the range of uses to which it can be applied will be wider, with potentially more wireless applications having efficient access to this valuable resource. Of all the applications, the category of electronic communications is the most promising. These applications include wireless broadband communications providing ubiquitous broadband access for all, additional terrestrial broadcasting services and mobile multimedia applications.

In social terms, making the digital dividend available for broadband, alongside spectrum in other bands, can help close the digital divide. Overall, the Internet usage will be nearly four times larger in 2013 than in 2009, while mobile data and Internet traffic will more than double every year in Europe. Additionally, the modern consumer and service subscriber are becoming more mobile and no longer accept limitations in applications and accessibility to content. As the demand for bandwidth to deliver ICT applications explodes, growing much faster than the current expansion of wireless networks, consumers need to be provided with appropriate access to delivery mechanisms to meet their needs. The "digital dividend" band could thus complement other mobile broadband frequency bands.

Some considerations are also provided regarding the "second digital dividend". From a mobile perspective, a second digital dividend could provide further access to valuable frequencies below 1 GHz, which would have numerous benefits, such as increasing the speed, capacity and coverage of mobile broadband, enabling worldwide roaming, or potentially providing new harmonized mobile spectrum to accommodate the needs of specialist users such as public safety services.

From a broadcasting perspective, a second digital dividend will be particularly problematic for digital terrestrial television channels, platforms and transmission/network providers, and in some cases may be costly to implement (if it is feasible at all). This is because many digital terrestrial television systems have already been re-planned once to make way for the first dividend, and although there are options to improve the capacity of digital terrestrial television networks — such as the use of MPEG 4 coding and migration from DVB T to DVB T2 (the newer generation of digital terrestrial television technology) — access to UHF spectrum is still essential in maintaining existing digital terrestrial television networks and enabling services to expand (for example, by creating more multiplexes to carry additional digital channels).

1.5 New services: Connected TV, Smart TV, Over the Top TV

With a "connected" television set, viewers can benefit the fruition of broadcast and Internet technologies simultaneously. From a single receiver, viewers can access live content using broadcast technology (i.e. DVB-T/T2) while supplemental services are provided over the Internet using broadband technology. Supplemental services can include information services such as news and weather, electronic programme guides, catch-up television, interactive advertisement, and also on-demand video.

These new types of advanced TV services known as Over-the-top (OTT), or smart-TV television can distribute TV contents or web-linear services through broadband connection across open networks accessible directly through the domestic television apparatus and / or through a variety of devices with an appropriate QOS (Quality Of Service). These over-the-top services are available on other networks and distributed through the Internet, "bypassing" thus television operators and telecommunications, and by extension they are called over-the-top. The natural evolution of this mode of use will be to migrate more toward the television screen while the distribution of web TV usually made on a "best effort" is improved through technological devices such as CDN which can guarantee a "quasi-managed".

The content delivery network (CDN) is capable of ensuring a better quality of service through a system of networked servers over the Internet that cooperate transparently, in the form of distributed system, to deliver content (especially large media content in terms of band) to end users. The goal of a CDN is to route a request for content on the node which is also identified as optimal geographically and make content available more efficiently. In this way the services that use this type of network architecture can rely on a quality of service comparable with the "managed" (see section on IPTV).

Various technologies are available to enable television sets to integrate broadcast and broadband services. In particular, from the point of view of the platforms configuration and business model, it is possible to individuate two classes of OTT platforms:

- Horizontal OTT platforms, developed on a consortium model, with the consensus of the various operators involved and based on open requirements and specifications;
- Vertical OTT platforms, based on proprietary specifications and managed by a single subject which can be named "packager" because it decides, selects and "packages" contents and Internet-delivered services (audiovisual, social network, news etc.) for the final user. Television manufacturers, Tlc operators and videogames operators belong to this second category.

Horizontal OTT platforms:

Three open standards, MHEG-IC, GEM/MHP, and HbbTV, have been developed for the provision of hybrid broadcast / broadband (HBB) television services in addition to the proprietary hybrid solutions made available by many top-brand consumer manufacturers.

HbbTV is an interactive middleware that makes use of existing broadcast and web technologies such as OIPF (Open IPTV Forum), CE-HTML, HTML and the DVB Application Signalling. Since its standardisation by ETSI in June 2010, deployment of the HbbTV standard is in early stages with commercial services so far available in Germany.. The HbbTV consortium has issued version 1.5 of its hybrid broadcast / broadband specification. This new version is based on the work of the HD Forum in France and its TNT 2.0 specification. Version 1.5 of the HbbTV specification provides support for HTTP adaptive streaming based on the recently published MPEG-DASH specification. This allows for an improved perception of the quality of video presentation on busy or slow Internet connections. Finally, version 1.5 of the specification improves access to broadcast television schedule information, allowing providers to produce 7-day EPGs that can be deployed across all HbbTV receivers.

MHEG-IC (Interaction Channel) is an extension of the MHEG interactive middleware and makes use of the same standard protocols used to deliver web content to computers, such as TCP-IP, HTTP and HTTPS. This standard is used in the United Kingdom for its Freeview HD (DVB-T2) and Freesat (DVB-S and DVB-S2) platforms.

GEM/MHP is an open standard for interactive services based on Java developed by the DVB Project for use on its broadcast delivery standards. Italy is the most extensive MHP market in Europe with over 10 million MHP-enabled receivers in homes.

Regarding proprietary solutions it is wortwhile to describe how major manufacturers of TV have marketed different Internet Enabled TV models that have on the back of the TV along with the regular antenna input, an Ethernet port to connect to the Internet. The standard TV remote control has a WEB button which brings up the display icons Widget Channel selectable and can be activated directly on the screen using the directional keys on the TV remote control. The connection to the Internet can be achieved by an ADSL modem or a wireless WiFi adapter connected to an ADSL modem. This new system provides access to a channel in the web as well as the radio or TV tuner receivers allow access to frequencies.

The interface is based on so-called widgets that are nothing more than graphical user interfaces (usually icons) displayed on the television screen which allow the possibility to access and view content available on the Internet . The Widgets can be written in any language (Java, NET, PHP and others) or may be a simple HTML fragment. A widget does not work like a normal web browser as it does not provide access to an entire web site, but provides access to a group of selected features of a website. For example, a weather widget allows you to receive real-time weather information and weather forecast for multiple locations. Widgets are connected with the major sites that offer streaming videos like YouTube, Yahoo Sports, Yahoo Finance, eBay and Blockbuster, and there are also ads in the press that Skype is available from these types of televisions allowing in this way to make video calls through their home television.

2 ANNEX 2: Strategies and Regulations to deploy digital broacasting technology in the EU

2.1 Digital terrestrial television

'eEurope 2005: An information society for all - An Action Plan to be presented in view of the Sevilla European Council 21/22 June 2002' – May 28, 2002 COM (2002) 263

The objective of this 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 participate in the global information society. eEurope 2005 therefore aims to stimulate secure services, applications and content based on a widely available broadband infrastructure.

The Action Plan stated that in order to speed up the transition to digital television, Member States should create transparency as far as the conditions for the envisaged switchover are concerned and Member States should publish by end 2003 their intentions regarding a possible switchover. These could include a road map, and an assessment of market conditions, and possibly a date for the closure of analogue terrestrial television broadcasting which would enable the recovery and re-farming of frequencies. National switchover plans should also be an opportunity to demonstrate a platform-neutral approach to digital television, taking into account competing delivery mechanisms (primarily satellite, cable and terrestrial).

Communication of the European Commission on the transition from analogue to digital broadcasting (from digital 'switchover' to analogue 'switch-off') – September 17, 2003 COM (2003) 541

The present Communication is the first comprehensive attempt to assess the issues invoked by switchover. The Communication states that 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. The Communication addressed the switchover process, which is a complex process with social and economic implications going well beyond the pure technical migration with a special focus on Member States' policies for digital TV migration and suggested the type of information that could be included in national switchover plans.

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 characterise 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 analyze 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

It was not envisaged to propose a common switch-off date or the prohibition of selling analogue receivers at EU level.

Communication of the European Commission on accelerating the transition from analogue to digital broadcasting – May 24, 2005 COM (2005) 204

This Communication builds on the 2003 Communication on the transition from analogue to digital broadcasting (from digital 'switchover' to analogue 'switch-off')[1] and, in the light of Member States' switchover plans[2] published within the framework of the eEurope action plan, and a recent opinion of the Radio Spectrum Policy Group[3] proposes a deadline for switch off of analogue terrestrial broadcasting throughout the EU.

The Communication states that the switchover can provide consumers with improved broadcasting services and many new services beyond traditional broadcasting; it may also contribute to serve better the specific needs of people with disabilities. Switchover brings immediate benefits at Member State level. There is scope for an acceleration of national switchover processes in order to achieve benefits for the EU as a whole.

The Communication points-out that in some geographic areas, the terrestrial switchover process has already been completed and analogue terrestrial broadcasting has been discontinued. Some Member States plan to complete the national terrestrial switchover process during the next few years. As a result, the Commission expects that by the beginning of 2010 the switchover process should be well advanced in the EU as a whole and proposes that a deadline of the beginning of 2012 be set for completing analogue switch-off in all EU Member States.

Flexibility is needed to ensure that the spectrum currently used for analogue terrestrial broadcasting is reused in a way that provides the most value to society and to the economy. All potential applications for the use of these frequencies should be considered, and any allocation and assignment procedures must ensure fair access for all potential users. The availability of a part of the spectrum dividend at EU level would facilitate the uptake of new pan-European services and applications and the Commission will examine the feasibility of a co-ordinated approach.

Commission reccomandation of 28 October 2009 facilitating the release of the digital dividend in the European Union (2009/848/EC)

The Reccomandation recognizes that it is essential to ensure a coherent policy at European level regarding the transition to digital technology and the switch-off of analogue broadcasting, so that this can be completed as quickly as possible in line with the early plans of certain Member States.

This Recommendation states that Member States should take all the measures necessary to ensure that all terrestrial television broadcasting services use digital transmission technology and cease using analogue transmission technology on their territory by 1 January 2012.

Furthermore the Commission that Member States should support regulatory efforts towards harmonised conditions of use in the Community of the 790-862 MHz sub-band for electronic communications services other than, and in addition to, broadcasting services, and refrain from any action that might hinder or impede the deployment of such communications services in that sub-band.

2.2 Digital dividend - Spectrum

Communication of the European Commission on 'Reaping the full benefits of the digital dividend in Europe: A common approach to the use of the spectrum released by the digital switchover' – November 13, 2007 COMM (2007) 700

The Communication described the benefits of the digital dividend to be freed up by the switchover from analogue to digital terrestrial TV by the end of 2012. The digital dividend may be used for wireless broadband communications services, but also for Additional terrestrial broadcasting services and mobile multimedia, since broadcasters should be able to claim a fair stake in the digital dividend in return for their efforts and investment in the digital switchover.

The most optimal use of the digital dividend is only possible if Member States work together and if the EU dimension of spectrum planning for the digital dividend is reinforced. Accordingly, the Commission is proposing to move towards a common spectrum plan at EU level. Nevertheless, the Commission recognized that the spectrum situation may vary in each Member State depending on the specific broadcasting environment, in particular the extent of reliance on terrestrial TV, notably to support public service obligations. There are also clear differences of timing and strategy in national plans regarding the digital switchover which need to be considered. The common spectrum plan would therefore have to be phased in with sufficient flexibility to accommodate legitimate national specificities, such as local social and market needs.

European Parliament resolution on reaping the full benefits of the digital dividend in Europe: a common approach to the use of the spectrum released by the digital switchover – September 24, 2008 (2008/2009(INI))

The Resolution emphasized the need for digital switchover which, together with the development of new information and communication technologies and the digital dividend, will help to bridge the digital divide and contribute to the achievement of the Lisbon goals and noted the divergence in national regimes relating to spectrum allocation and exploitation; which differences may represent obstacles to the achievement of an effectively functioning internal market. The EP urged the Member States to release their digital dividends as quickly as possible (meaning the accomplishment of the digital switchover), allowing citizens of the Union to benefit from the deployment of new, innovative and competitive services; emphases that, for this purpose, the active cooperation between Member States to overcome obstacles existing at national level for the efficient (re)allocation of the digital dividend is required.

Communication of the European Commission on transforming the digital dividend into social benefits and economic growth – October 28, 2009 COM (2009) 586

The Communication stated that the digital dividend spectrum will become available throughout Europe within a relatively short space of time, as all Member States should complete the switch-off of analogue TV by 2012 at the latest. The Communication outlined a set of proposals for a common approach to the digital dividend in Europe.

The Communication emphasized that Member States which have not yet completed the digital switchover are requested to reaffirm their commitment to the effective switch-off of analogue TV broadcasting by accepting an EU target date of 1 January 2012, and to complete all the necessary preparatory measures, since the digital dividend will only become fully available after the switch-off of analogue broadcasting.

Communication of the European Commission on "A Digital Agenda for Europe" COM (2010) 245 – August 26, 2010

According to the Communication the Commission intends to coordinate the technical and regulatory conditions applying to spectrum use and, where necessary, harmonize spectrum bands to create economies of scale in equipment markets. As a guiding principle, it is stated that a forward-looking European spectrum policy should, while accommodating broadcasting, promote efficient spectrum management, by mandating the use of certain digital dividend frequencies for wireless broadband by a fixed future date, by ensuring additional flexibility (also allowing spectrum trading) and by supporting competition and innovation. The Commission also will ensure the implementation of the provisions of the Audiovisual Media Services Directive concerning cultural diversity, where appropriate through co- and self-regulation and request information from Member States on their application.

Commission Decision of 6 May 2010 on "Harmonised technical conditions of use in the 790-862 MHz frequency band for terrestrial systems capable of providing electronic communications services in the European Union

This Decision aims to harmonise the technical conditions for the availability and efficient use of the 790-862 MHz band (800 MHz band) for terrestrial systems capable of providing electronic communications services in the European Union. Therefore if Member States decide to change the existing frequency allocation (for broadcasting) they must immediately apply the harmonised technical rules laid down by the Decision to make these frequencies available to wireless broadband applications.

The technical conditions presented in the Annex of the Commission decision are in the form of frequency arrangements and block-edge masks. Regarding frequency arrangements within the band 790-862 MHz shall be as follows:

(a) the assigned block sizes shall be in multiples of 5 MHz;

(b) the duplex mode of operation shall be FDD with the following arrangements. The duplex spacing shall be 41 MHz with base station transmission (down link) located in the lower part of the band starting at 791 MHz and finishing at 821 MHz and terminal station transmission (up link) located in the upper part of the band starting at 832 MHz and finishing at 862 MHz.

The Annex lists also technical conditions for FDD or TDD base stations (BS) and limits on BEM, and other technical parameters..

This decision does not itself require Member States to make available the 790-862 MHz band for electronic communication services. However, the Commission is considering such a proposal in the forthcoming Radio Spectrum Policy Programme, which will take account of a recent consultation on the subject.

Decision No 243/2012/EU of the European Parliament and of the Council of 14 March 2012 establishing a multiannual radio spectrum policy programme

The Radio Spectrum Policy Programme was officially published today, in the March 21 Official Journal of the European Union. The Decision establishes a multiannual radio spectrum policy programme for the strategic planning and harmonisation of the use of spectrum to ensure the functioning of the internal market in the Union policy areas involving the use of spectrum, such as electronic communications, research, technological development and space, transport, energy and audiovisual policies.

While spectrum management is still largely a national competence, it should be exercised in compliance with existing Union law and allow for action to pursue Union policies. In line with the objectives of the Digital Agenda for Europe, wireless broadband could contribute substantially to economic recovery and growth if sufficient spectrum were made available, rights of use of spectrum were awarded quickly, and trading were allowed to adapt to market evolution. The Digital Agenda for Europe calls for all Union citizens to have access to broadband at a speed of at least 30 Mbps by 2020. Member States shall, in cooperation with the Commission, take all steps necessary to ensure that sufficient spectrum for coverage and capacity purposes is available within the Union, in order to enable the Union to have the fastest broadband speeds in the world, thereby making it possible for wireless applications and European leadership in new services to contribute effectively to economic growth, and to achieving the target for all citizens to have access to broadband speeds of not less than 30 Mbps by 2020.

By 1 January 2013, Member States shall carry out the authorisation process in order to allow the use of the 800 MHz band for electronic communications services. The Commission shall grant specific derogations until 31 December 2015 for Member States in which exceptional national or local circumstances or cross-border frequency coordination problems would prevent the availability of the band, acting upon a duly substantiated application from the Member State concerned.

A non-binding recital states that additional spectrum could also be envisaged in the long term following a future analysis of technical trends and spectrum needs.

World Radiocommunications Conference 2012 (WRC-12)

It is worthwhile to mention some results of the World Radiocommunications Conference 2012 (WRC-12) in Geneva under the auspices of the International Telecommunications Union (ITU). National administrations reviewed the outcome of studies on the use of the frequencies from 790-862 MHz by mobile applications, agreed further studies on the introduction of “white-space” devices, and the proposed agenda for the next World Radiocommunications Conference to be held in 2015 (WRC-15).

But most controversially, the WRC-12 agreed to a proposal from participants from Africa and the Middle East, for the introduction of mobile services in the frequencies from 694-790 MHz which had been allocated to broadcast services on a primary basis. By doing so, Region 1, which comprises countries in Africa, Europe and parts of Asia, will harmonise the use of the 700 MHz band with other Regions of the world after 2015.

Following the proposal from national administrations in Africa and the Middle East, the WRC-12 approved Resolution Com 5/10 that allocated the frequency band from 694-790 MHz in Region 1 to the mobile services on a co-primary basis with other services, including broadcast services. However, this allocation does not take effect until after the next World Radiocommunication Conference in 2015 when the technical and regulatory conditions for this allocation will be defined.

National administrations also decided on the necessity to undertake further studies as part of their agreement to Resolution Com 5/10. As a result, the ITU has been mandated to undertake extensive studies on:

- ▪ the spectrum requirements for mobile and broadcast services in the 700 MHz band,
- ▪ the channeling arrangements for mobile services in the 700 MHz band,
- ▪ the compatibility between mobile and broadcast services, and,
- ▪ the possible solutions for PMSE services using the 700 MHz band (Programme Making and Special Events services are widely used by broadcasters and the entertainment business for wireless microphones in large productions).

In the first meeting to begin the preparations for WRC-15, participants decided that a new Joint Task Group, JTG 4-5-6-7 will be responsible for these studies. It will bring together the ITU study groups on satellite (group 4), terrestrial services (group 5), broadcasting (group 6) and science services (group 7).

While the allocation of the 700 MHz band will remain unchanged until 2015, this decision highlights the desire by national administrations to allocate further frequencies below 1 GHz to mobile services. The strong push from countries in Africa and the Middle East also highlights the importance of mobile services as the primary delivery option for the provision of broadband services. This is less obvious in Europe where many countries have allocated the 800 MHz band for mobile broadband services and intensively use the 700 MHz band for digital television services.

2.3 Interactivity and conditional access

Directive 95/47/EC of the European Parliament and of the Council of 24 October 1995 on the use of standards for the transmission of television signals

Such Directive stated some conditions related to conditional access systems. In particular, the Directive set the following conditions :

(a) all consumer equipment, for sale or rent or otherwise made available in the Community, capable of descrambling digital television signals, shall possess the capability:

- to allow the descrambling of such signals according to the common European scrambling algorithm as administered by a recognized European standardization body,

- to display signals that have been transmitted in clear provided that, in the event that such equipment is rented, the rentee is in compliance with the relevant rental agreement;

(b) conditional access systems operated on the market in the Community shall have the necessary technical capability for cost-effective trans-control at cable head-ends allowing the possibility for full control by cable television operators at local or regional level of the services using such conditional access systems;

(c) Member States shall take all the necessary measures to ensure that the operators of conditional access services, irrespective of the means of transmission, who produce and market access services to digital television services:

- offer to all broadcasters, on a fair, reasonable and non-discriminatory basis, technical services enabling the broadcasters' digitally-transmitted services to be received by viewers authorized by means of decoders administered by the service operators, and comply with Community competition law, in particular if a dominant position appears,

- keep separate financial accounts regarding their activity as conditional access providers.

(d) when granting licences to manufacturers of consumer equipment, holders of industrial property rights to conditional access products and systems shall ensure that this is done on fair, reasonable and non-discriminatory terms. Taking into account technical and commercial factors, holders of rights shall not subject the granting of licences to conditions prohibiting, deterring or discouraging the inclusion in the same product of:

- a common interface allowing connection with several other access systems, or
- means specific to another access system, provided that the licensee complies with the relevant and reasonable conditions ensuring, as far as he is concerned, the security of transactions of conditional access system operators.

Where television sets contain an integrated digital decoder such sets must allow for the option of fitting at least one standardized socket permitting connection of conditional access and other elements of a digital television system of the digital decoder;

Directive 2002/19/EC of the European Parliament and of the Council of 7 March 2002 on access to, and interconnection of, electronic communications networks and associated facilities (Access Directive)

This Directive defines the conditions for access to digital television and radio services broadcast to viewers and listeners in the community. In relation to conditional access to digital television and radio services broadcast to viewers and listeners in the Community, irrespective of the means of transmission, Member States must ensure that the following conditions apply:

(a) conditional access systems operated on the market in the Community are to have the necessary technical capability for cost-effective trans-control allowing the possibility for full control by network operators at local or regional level of the services using such conditional access systems;

(b) all operators of conditional access services, irrespective of the means of transmission, who provide access services to digital television and radio services and whose access services broadcasters depend on to reach any group of potential viewers or listeners are to:

- offer to all broadcasters, on a fair, reasonable and non-discriminatory basis compatible with Community competition law, technical services enabling the broadcasters' digitally-transmitted services to be received by viewers or listeners authorised by means of decoders administered by the service operators, and comply with Community competition law,

- keep separate financial accounts regarding their activity as conditional access providers.

(c) when granting licences to manufacturers of consumer equipment, holders of industrial property rights to conditional access products and systems are to ensure that this is done on fair, reasonable and non-discriminatory terms. Taking into account technical and commercial factors, holders of rights are not to subject the granting of licences to conditions prohibiting, deterring or discouraging the inclusion in the same product of:

- a common interface allowing connection with several other access systems, or

- means specific to another access system, provided that the licensee complies with the relevant and reasonable conditions ensuring, as far as he is concerned, the security of transactions of conditional access system operators.

Communication from the Commission to the Council, the European Parliament, the European Economic and Social committee and the Committee of the Regions on interoperability of digital interactive television services [SEC(2004)1028]

This Communication sets out the Commission's position on interoperability of digital interactive television services pursuant to Art. 18(3) of Directive 2002/21/EC on a common regulatory framework for electronic communications networks and services (the Framework directive). The Commission concludes that there is no clear case for mandating standards at present; the issue should be reviewed in 2005. Meanwhile, a range of promotional actions are proposed to promote the deployment of interactive digital services using the Multimedia Home Platform (MHP) standard, currently the only open standard for APIs adopted by EU standards bodies. These include the creation of a Member State group on MHP implementation, confirmation that Member States can offer consumer subsidies for interactive television receiver equipment, subject to conformity with state aid rules, and monitoring of access to proprietary technologies.

Communication of 2 February 2006 from the Commission to the Council, on reviewing the interoperability of digital interactive television services pursuant to Communication COM(2004) 541 of 30 July 2004 [COM(2006) 37 - Not published in the Official Journal].

This communication reports on an assessment of developments in the digital interactive television sector since publication of the last communication on this subject in July 2004.

Developments on this market have led the Commission to consider the effectiveness of interoperability in digital interactive television. It highlights the roll-out of digital interactive television in Europe via applications programme interfaces (or API standards) and the involvement of various players.

3 ANNEX 3 : NEW TECHNOLOGIES AND SERVICES IN THE EU:

3.1 Switch-off

At the end of 2011 analogue terrestrial switch-off has taken place in 20 European countries:

Austria, Belgium, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Iceland, Latvia, Luxembourg, Malta, the Netherlands, Norway, Slovenia, Spain, Sweden and Switzerland.

A further eight EU countries are expected to complete ASO (the United Kingdom, Greece, Ireland, Italy, Lithuania, Portugal, the Czech Republic and Slovakia) in 2012

The strategies chosen by the different European Countries for the achievements of their objectives in term of transition to DTT can be somehow grouped into two main groups of Countries.

Hereafter a European Benchmark of the methods and economic conditions for the awarding of the license to DTT MUX operators.

3.2 Transition Strategies:

In a first group of European countries (France, Belgium, Germany, Finland, Sweden, etc) the DTT channels line-up has been pre-defined by public authorities. The order of this line-up normally includes the channels (public and private) already operating with the analog signal. For the "new" digital channels Authorities have chosen a method of selection called Beauty Contest based on the following criteria:

- The ability to meet the needs of a wide public and likelihood to engage in rapid development of digital terrestrial television;
- The need to ensure effective competition and diversity of operators;
- Safeguarding media pluralism, socio-cultural diversity, needs of minorities, vulnerable groups, etc.;
- Experience in the media sector;
- Commitments on production and distribution of audiovisual and cinematographic works;
- Liabilities for the coverage of the territory;
- Coherence of proposals for consolidation of distributors and choice of services;
- Funding and prospects of service provision;
- Coherence of the proposal in terms of grouping and service distribution (pay vs. free, current agreements for Mux management, etc.);
- Operator’s financial plan.

It seems obvious that channels already present in the analog transmission have not been subject to the Beauty Contest and their DTT transmission has been automatically authorized.

Once the line-up has been defined, each Country's Authority has defined the number of MUX necessary for the broadcasting of the channels and which channel would be broadcast in each MUX.

Normally, after this phase, broadcasters belonging to the same MUX, have created a consortium responsible for the operation and management of the MUX and have received approval by the Authority, which, in the majority of cases has granted (free) license to operate the frequencies necessary to guarantee coverage of the DTT broadcasting.

The second approach (U.K., Austria, Denmark, Italy, etc) allows for the capacity management to be performed directly by the multiplex/network operator affording it relative freedom in terms of capacity utilization of the Mux and in the selection of the channels which will be carried by the Mux. In this scenario, the multiplex operator acts as a gatekeeper and the capacity is managed as a whole by a multiplex/network operator who enjoys some leeway in using the capacity and selecting the channels which compose the line-up. However, some public interest criteria are still preserved, such as fair competition, diversity and pluralism. In view of these criteria the usual limitations or constraints are set in the form of:

- “must-carry” provisions requiring the multiplex operator to carry specific programmes;
- transparency of prices, requiring multiplex operators to make public specified information, such as Mux capacity prices, technical specifications, network/interface characteristics, terms and conditions for supply and use;
- cost-oriented prices, (fair prices based on costs and investments made by the operator allowing him a reasonable rate of return on adequate capital employed, taking into account the risks involved);
- non-discrimination principles between operators, avoiding different prices and conditions by ensuring, in particular, that the operator applies the same conditions in the same circumstances to other undertakings providing same services.

In some cases Authorities have gone to the extent of defining specific regulations on commercial agreements (price and conditions) between MUX operators and content providers.

In this second group of countries commercial clauses have usually been established by the MUX operators and include an initial "one shot" expense combined with an annual fee. Experience showed that in these countries prices have been maintained reasonable; in some cases frequencies have been released free of charge.

It's interesting to note that in most countries the annual fee has been based on technical parameters exclusively: network, coverage, transmitters, band and transmission power.

Only in a few cases, the price has been linked to the operators turnover.

3.3 Growth in the number of platforms and operators

As DTT roll-out continues, the number of operators also continues to grow. This reflects both the recent launches of DTT in several countries, and also the addition of new Pay DTT services, or regional/local multiplexes in others.

In the EU Countries in December 2010 there were 76 MUX Operators and 28 DTT Packages.

Less than 6 months later, in May 2011 the number of operators had risen to 82 and the number of DTT packages to 32.

Pay DTT services in June 2011

Pay DTT services are available in 14 EU countries. National channels and are evenly divided between Pay (53%) and FTA (47%) platforms. Local channels appear primarily on the FTA DTT platforms. At the end of 2011, 31 pay-TV platforms were available in 19 European countries.

Public and private

The public channels continue to play an important role on the FTA platforms (more than one third of these are public channels) but logically less so on the pay platforms (less than 10% are public).

3.4 Growth of technologies

3.4.1 HD channels/MPEG-4

HD channels are now available on DTT networks in 18 countries (as compared to 3 networks at the end of 2009 and to 8 in October 2010).

HD channels are available on both FTA and Pay platforms in most of these countries (except Latvia and Lithuania where HD is on Pay DTT only). On the FTA platforms, the channels are the simulcast or HD versions of the major national public and private generalist channels. On the pay TV platforms the HD channels are niche channels, film channels and pan-European documentary channels.

MPEG-4 is usually utilized for the compression of HD signals.

3.4.2 3D TV

3D DTT tests are being carried out in several EU countries (Italy, the Netherlands, Spain, Sweden, the United Kingdom etc.). 3D VoD is already available in Italy. 3D TV contents have been broadcast at first on satellite but recently trials are also on terrestrial. In Europe, British Sky Broadcasting (Sky) launched a limited 3D TV broadcast service on 3 April 2010. Transmitting from the Astra 2A satellite at 28.2° east, Sky 3D broadcast a selection of live UK Premier League football matches to over 1000 British pubs and clubs equipped with a Sky+HD Digibox and 3D Ready TVs, and preview programmes provided for free to top-tier Sky HD subscribers with 3D TV equipment. This was later expanded to include a selection of films, sports, and entertainment programming launched to Sky subscribers on 1 October 2010. Sky 3D, the UK's first and only dedicated 3D TV channel. Sky 3D is now available in more than 250,000 Sky homes as well as thousands of pubs nationwide. Eurosport's comprehensive 3D coverage of the London 2012 Games is to be made available to all '3D Ready' Sky+HD homes. Eurosport, the pan-European broadcaster of the London 2012 Olympics, will broadcast more than 100 hours of 3D action over the course of this summer's Games

Other European satellite pay-tv broadcasters (Canal+, SKY ITALIA, etc.) have also launched their 3D TV broadcast services.

More recently 3D TV contents have been broadcast also on DTT. In 2010 UK Broadcast network operator Arqiva planned a trial of 3D TV broadcast over the countries terrestrial network. In June 2011 Public service broadcaster BBC provided 3D coverage of the men's and women's final of the Wimbledon Tennis Championship on the DTT platform. It is estimated that the 3D content was viewed by 18,000 households. At that time there were approximately 200,000 3D receivers in the UK. The free-to-air transmissions was available to anyone with a 3DTV, regardless of which TV provider they use, also making the broadcast the first commercial 3D transmission on the UK's terrestrial system. In Sweden Pay-DTT service operator Boxer broadcast two sporting matches in 3D on the DTT platform during April 2011. 3D TV Tests are currently ongoing in other European countries.

Also in Italy, Spain and France trial are currently conducted for 3D TV services.

In 2011 Telecom Italia Media Broadcast (TIMB) has launched Italy's first HD DTT service carrying live 3D content. The service is carried through the LA7 channel. In 2011Motive Television has announced the launch of a 3D on-demand service over Mediaset's DTT network using its Bestv software. The service, 3VOD, delivers 3D on-demand content over the air to non-connected set-tops using spare terrestrial capacity.

3.4.3 Interactivity

Several systems have been introduced in Europe to implement interactivity on DTT.

Initial deployments of MHP were in broadcast markets, over satellite (DVB-S) by Skylife in Korea, and terrestrially (DVB-T) by MTV3 Oy in Finland. Since then, the uptake of broadband has meant that many recent MHP deployments have been in hybrid broadcast/broadband networks, where the broadcast network is using the broadband network for complementary information, applications and, only recently, video. Other key markets for MHP include Italy (DVB-T), Austria (DVB-T/DVB-C), Spain (DVB-T).

MHEG-5 is used by Freeview and Freesat in the UK. The UK DTG has completed extensions to support HD services that will be used on the Freesat platform in the UK from May 2008. An 'Interaction Channel' extension has also been defined to enable IP connectivity in addition to broadcast delivery of applications and content and PVR integration is also in development.

3.4.4 DVB-T2

Interest in launching DTT networks using the DVB-T2 standard has been high and demonstrates the vibrancy of the DTT platform. Numerous DVB-T2 trials are underway across Europe as many DTT operators look favorably upon the bit-rate capacity gain possible with DVB-T2 in comparison with DVB-T. For many countries, DVB-T2 will allow for the launch of HDTV services on the terrestrial platform. Since ETSI standardized DVB-T2 in September 2009, three countries (Sweden, United Kingdom, and Italy) have launched commercial services using DVB-T2 while several further countries have announced plans to launch DVB-T2 platforms.

The first country that deployed DVB-T2 is the UK, where DVB-T2 services were launched in March 2010, next to an existing DVB-T service. 2010 and 2011 also saw the launch of DVB-T2 services in Italy, Sweden, and Finland, all of which will be nationwide in the short term. Outside of Europe DVB-T2 pay-TV services were launched in Zambia, Nigeria, Kenya and Uganda and many more are expected to follow soon. Advanced trials are currently taking place across the globe and more countries are considering DVB-T2 services, bringing the total of DVB-T2 countries to 47.

In Russia the government decided to bring forward its launch plans for the DTT platform using the DVB-T2 standard. The deployment of the DVB-T2 platform should take place in 7 regions during 2012. The DVB-T2 platform was launched in early March in Tatarstan where it is available to 1.5 million residents. The DTT platform in Tatarstan launched with services available to 40% of the population. Coverage will increase to reach 70% of the population by the end of the year and 100% of the region's population by 2015.

Analogue switch-off to be completed in 2015.

Next, the platform will launch in the areas of Krasnodar, Volgograd, Rostov and Pskov. By the end of 2012, 70% of the population should have access to the DVB-T2 platform.

UK

United Kingdom was the first country in the world to launch commercial services based on the new DVB-T2 standard. As of 2010, in the UK terrestrial television system, there is one multiplex assigned to digital broadcasting in the DVB-T2 standard and by using MPEG-4 encoding. This multiplex is controlled by the service company Freeview HD, which has offered to host up to five DVB-T2 HD channels on it. Freeview HD started its "technical launch" on December 2, 2009, hosting BBC HD, and ITV1 HD. In 2010 Freeview HD had its official launch, and added Channel 4 HD whilst the fourth channel hosted is BBC One HD. The remaining fifth slot is still to be assigned. Freeview, the UK's largest digital TV service, has sold more than three million Freeview DVB-T2 HD devices. At the end of 2011 80% of the UK can receive HD through Freeview which will increase to the whole country when digital switchover is completed in October 2012.

SWEDEN

In Sweden HDTV services transmitted via DVB-T2 were officially launched on the 1st November 2010. The broadcast network operator Teracom has been responsible for building and operating the DVB-T2 network which consists of two multiplexes, Multiplex 6 and Multiplex 7. At launch these two multiplexes began HD broadcasting to two thirds of TV homes. Coverage will reach 70% of the population by the end of 2010 increasing to 90% over a further 12 month period and 98% by the end of 2012. Viewers will have access to two free to air services, SVT1 HD and SVT1 HD as well as the Pay TV channels MTVN HD, National Geographic HD, TV4 HD (as of 18 December), Canal+ Sport HD from the Pay-DTT service provider Boxer. The HD services use both UHF and VHF channels for HD broadcasting.

On UHF multiplex 6 is completely HD whilst a combination of spare UHF and VHF channels are used for the second multiplex, designated "multiplex 7". 8 MHz channels are used on UHF and on VHF the channel bandwidth is 7 MHz due to previous standardisation.

The DVB-T2 network parameters used in Sweden are similar to the ones chosen in the United Kingdom for their DVB-T2 network. However, because of the large Single Frequency Networks (SFNs) in Sweden, different guard intervals have been used which has lowered the bit-rate capacity, but allowed for more efficient frequency planning. The resulting capacity on multiplex 6, is 36.6 Mbit/s and on multiplex 7, 30.8 Mbits/s. The parameters used initially in the DVB-T2 networks will be single-PLP, 32K FFT, 256 QAM and a code rate of 2/3 although these parameters may be varied for different SFN sizes. MPEG-4 HE-AAC audio compression is used for all MPEG-4 services. HD services will typically be accompanied by 5.1 surround sound.

ITALY

The commercial broadcaster Europa 7 launched DTT HD services using the DVB-T2 standard on VHF Band III in 2010.

Europa 7 distributes its DTT set-top box, 7 Box HD which will allow viewers to access 8 pay HD television services. The 7Box HD will be capable of receiving DVB-T2 programmes and DVB-T programmes.

In April 2012 the Italian government has decided that all DTT tuners sold in Italy from 2015 onwards must include the DVB-T2 standard, both for stand-alone set tops and for IDTVs. For consumers, there will be a need to buy new tuners, although a number of DVB-T channels will remain on air for some time. The government has announced that as of 2015, all DTT receivers must include a tuner with the DVB-T2 standard.

FINLAND

Finnish DTV operator DNA has become one of the first in the world to set up a DVB-T2 terrestrial infrastructure using a single-frequency network (SFN) configuration. The three multiplexes awarded to DNA earlier this year will deploy HDTV signals to 80% of all Finnish TV households using DVB-T2, MPEG-4 coding and Single Frequency Networks (SFN).

FRANCE

The broadcast trial platform, ImaginLab, has selected the broadcast network operator TDF as its technical operator for its DVB-T2 trial. The trial will take place in Rennes, in the northwestern part of France, and will launch in the first half of 2012. Currently, the DTT platform uses the DVB-T standard and both the MPEG-2 and MPEG-4 AVC compression standards. However, the broadcast regulator CSA has recommended that the transition to MPEG-4 AVC take place by 2015 and the transition to DVB-T2 take place by 2020.

The trial aims to better understand the issues related to the roll-out of DVB-T2 networks and receivers.

AUSTRIA

Austria media authority KommAustria has announced the creation of two new nationwide DTT multiplexes. The multiplexes MUX D and E will use the DVB-T2 standard.

DVT-2 has been chosen because it will allow more channels to be broadcast in the same spectrum as that used for a DVB-T multiplex. Up to 20 new SD TV programmes could be made available in the two new multiplexes.

The multiplexes Mux E and Mux D will have nationwide coverage and ORS would use the DVB-T2 standard to provide up to 30 TV channels some of which would be in HD.

The DVB-T2 tender closed for applications on the 15th November 2011 and if ORS wins, it plans to start services in 2012.

CROATIA

After successful analogue to digital switchover in Croatia by the end of 2010, first test transitions of DVB-T2 service commenced in 2011. In October 2011, after completing tendering procedure, HAKOM issued license for two DVB-T2 multiplexes to the national consortium (HP Produkcija, OIV and Croatian Post). HP Produkcija, Croatian Post and Croatia's national transmission company OiV, have signed a 10-year digital TV cooperation agreement. As a result, the consortium will start operation of two DTT multiplexes (MUX C and MUX E) in the mid of 2012, employing DVB-T2 technology, and eventually, in year 2014, will achieve coverage of more than 94% of the country population. Provided Pay-TV service will offer more than 30 SDTV and HDTV programmes.

GERMANY

Bayerische Rundfunk (BR), the public broadcaster for Bavaria, has launched a DVB-T2 test transmission in the city of Munich. The broadcasts of both SD and HD content are from the Freimann transmitter using programme material from Das Erste HD, Das Erste and Bayerische Fernsehen. The transmissions, which are for test purposes only, are Free to air and available on channel 50. The BR tests follow earlier transmissions in Munich from IRT.

The tests will be extended to a three transmitter Single Frequency Network during 2011

3.4.5 SFN

The European Union (EU) has been encouraging SFN deployment despite resistance from some member states, holding workshops on the subject, while the European Broadcast Union (EBU) has published guidelines for implementation.

ITALY

The Italian frequency planning (AGCOM resolution n. 300//10/CONS) states that the national DTT networks shall utilize SFN.

FINLAND

Finnish DTV operator DNA has become one of the first in the world to set up a DVB-T2 terrestrial infrastructure using a single-frequency network (SFN) configuration. The three multiplexes awarded to DNA earlier this year will deploy HDTV signals to 80% of all Finnish TV households using DVB-T2, MPEG-4 coding and Single Frequency Networks (SFN).

PORTUGAL

Several other European operators also are working on SFN deployment, including Portugal Telecom, which has been implementing SFN across a national network comprising more than 100 transmitters.

GERMANY

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3.4.6 HYBRID TELEVISION/OTT TV

The outlook for television receivers connected to the Internet is very positive. According to Strategy Analytics, 42 million households already watch content worldwide from the Internet on their television sets while Digital TV Research predicts that 551 million television sets will be connected to the Internet by 2016. The means for accessing such content vary. Strategy Analytics forecasts that the global sales of Internet-connected TV set-top boxes will more than double in 2011 compared to 2010. The market for "connected" television sets is also growing. A study by DisplaySearch shows that the number of units shipped per year worldwide will rise from 40 million in 2010 to 123 million in 2014.

As seen in detail in chapter 1.5, various technologies are available to enable television sets to integrate broadcast and broadband services. In particular, from the point of view of the configuration of the platforms and the business model, it is possible to individuate two classes of OTT platforms:

- Horizontal OTT platforms;
- Vertical OTT platforms.

With regard to horizontal platforms, the main European initiatives are currently:

3.4.6.1 YouView:

Developed in the United Kingdom by the collaboration between leading broadcaster of free TV (BBC, ITV, Channel 4 and Five) and telecoms operators BT, Talk Talk and Arqiva. Compared to the originally planned schedule, the project experienced some delays and probably the first YouView receivers, allowing access to a wide range of Internet content and applications (including offers of large catch-up TV broadcaster) next to the transmissions Freeview satellite, will be available only in 2012.

3.4.6.2 HbbTV:

Hybrid Broadcast Broadband Television is a pan-European open specification for interactive television delivered over both broadcast and broadband Internet connections, delivering information and entertainment services to HbbTV-enabled set-top boxes and iDTV. The HbbTV specifications have been approved by ETSI (ETSI TS 102 796) and is based on a number of existing standards including OIPF (Open IPTV Forum), DVB, W3C and CE-HTML. Services such as digital teletext, catch-up TV, electronic programme guides, interactive advertising, games and voting are all possible with HbbTV and many services are already being provided by broadcasters in France and Germany. In fact some major German and French broadcasters who support the initiative along with fifty others, have already launched HbbTV services . For example, Arte and ZDF offer catch-up (on-demand) TV services . The organisation responsible for specifying the common platform for digital television in the Nordic region, NorDig, has selected the HbbTV standard for broadcast / broadband services on the satellite, cable and DTT platforms. The HbbTV standard replaces MHP standard which had previously been selected as the common API for interactive services. Currently, the HbbTV standard version 1.1.1 has been added to the NorDig's Unified IRD specification (v2.2.1 and v2.3) as a separate addendum. However, it will be included in the main NorDig Unified IRD specification when the next version of the NorDig specification is issued. The NorDig specification is used in Denmark, Finland, Iceland, Norway, Sweden, and Ireland. France 5, a television programme service from the public service broadcaster France Télévisions, has announced that it will launch interactive broadcast / broadband services using the HbbTV standard on 10 April.

From the technical point of view the following provides some technical insight of the HbbTV ETSI Standard. A hybrid terminal has the capability to be connected to two networks in parallel. On the one side it can be connected to a broadcast DVB network (e.g. DVB-T, DVB-S or DVB-C). Via this broadcast connection the hybrid terminal can receive standard broadcast A/V (i.e. linear A/V content), application data and application signaling information. Even if the terminal is not connected to broadband, its connection to the broadcast network allows it to receive broadcast-related applications. In addition, signaling of stream events to an application is possible via the broadcast network.

In addition the hybrid terminal can be connected to the Internet via a broadband interface. This allows bi-directional communication with the application provider. Over this interface the terminal can receive application data and nonlinear A/V content (e.g. A/V content streaming on demand). The hybrid terminal may also support non-real time download of A/V content over this interface.

Via the Broadcast Interface the terminal receives AIT data, linear A/V content, application data and stream events. The last two data streams are transferred by using a DSM-CC object carousel. Therefore a DSM-CC Client is needed to recover the data from the object carousel and provide them to the Runtime Environment. The Runtime Environment can be seen as a very abstract component where the interactive application is presented and executed. The Browser and an Application Manager form this Runtime Environment. The Application Manager evaluates the AIT to control the lifecycle for an interactive application. The Browser is responsible for presenting and executing an interactive application.

Linear A/V content is processed in the same way as on a standard non-hybrid DVB terminal. This is included in the functional component named Broadcast Processing which includes all DVB functionalities provided on a common non-hybrid DVB terminal. Additionally some information and functions from the Broadcast Processing component can be accessed by the Runtime Environment (e.g. channel list information, EIT p/f, functions for tuning). Moreover an application can scale and embed linear A/V content in the user interface provided by an application. These functionalities are provided by the Media Player.

Via the Broadband Interface the hybrid terminal has a connection to the Internet. This connection provides a second way to request application data from the servers of an application provider. Also this connection is used to receive nonlinear A/V content (e.g. for Content on Demand applications). The component Internet Protocol Processing comprises
all the functionalities provided by the terminal to handle data coming from the Internet. Through this component application data is provided to the Runtime Environment. Non-linear A/V content is

forwarded to the Media Player which in turn can be controlled by the Runtime Environment and hence can be embedded into the user interface provided by an application.

3.4.6.3 Gold Sticker DGTVi:

It is an initiative developed by the Italian DTT platform, based on an evolution of the MHP standard for interactivity. Users owning the receiver (STB or iDTV) market with Gold Stamp, which identifies the predisposition to Internet connection, can access a series of advanced Internet-delivered services, including offers catch-up TV, Rai, Mediaset and LA7.

3.4.6.4 Business Models

From the point of view of broadcasters OTT TV is a major strategic challenge. The rise of new parties that are proposed as a package-enablers, in fact, tends to push them back one slot in the value chain. At this stage of market development, it is difficult to identify unique boadcasters strategies. On the one hand, traditional TV operators are among the main promoters of the consortium initiatives, as already mentioned YouView, HbbTV and Gold Sticker Freeview. These initiatives can be interpreted as an attempt by the broadcaster, to bring their offerings to the end user directly without going through an aggregator. On the other hand, we have seen, especially from 2010, to a multiplication of the distribution agreements between the new TV packagers of OTT TV (terminal manufacturers, operators of video games, etc..) and the broadcasters themselves, who propose to make available theirs audiovisual offers (particularly those catch-up TV) in OTT TV portals managed by aggregators.

Regarding the vertical-proprietary platforms, it is possible to draw up a list of subjects offering OTT services:

- Manufacturers of TV devices such as TVs sets and Set-Top-Box: Starting from 2010 all the major TV manufacturers have built into their TV equipment the possibility to access Internet and a range of content and services, varying from country to country, accessible through a portal owner. Generally, these platforms provide direct access to some Web services industry (such as YouTube, Dailymotion or in some cases offers catch-up TV broadcaster) and other Web services like Facebook, Flickr, Twitter or Yahoo!. Among the main players in this segment are among Sony (Sony Internet TV platform), Philips (Net TV), Samsung (Internet @ TV) and LG.
- Operators of the market for video games, like Sony, Nintendo, Microsoft, etc.. Their "new generation" console (PlayStation 3, Wii and XBox, respectively) are in fact prepared to offer Internet access and, along with interactive services closely related to the field of video games (download titles, multiplayer online etc.) also some Internet audiovisual services (eg YouTube, catch-up TV offers broadcasters, video rental services like Netflix - is in the U.S. on all three consoles).

- TLC operators, which aim to integrate new Internet-delivered services directly within their IPTV platforms (this is the strategy adopted by the major French operators) or to develop and market ad hoc OTTV platforms which may be accessible via STB or integrated into other connectable device. Among the many examples it can be mentioned the OTT TV offers by Vodafone TV (in Italy and Spain), the platform CuboVision by Telecom Italy or the availability of Chili FastWeb in Italy .
- Pay TV operators, which in recent months launched OTT TV services directly integrated by TV "traditional" linear. For example, Pay-TV operator BSkyB has launched in UK the offer Sky Anytime +, with a selection of about 1,000 titles available "on demand" to users who have the Sky + HD STB. More recently, the Pay-TV Italian DTT operator Mediaset has launched a new offer, Premium Net TV, with over 1,000 hours of content, including HD, of which over 200 films.
- Operators coming from the computer world (like Apple) or native of the Internet (Google, Yahoo, etc,.). The OTT Apple offer, Apple TV, was relaunched in October 2010 after the limited success of the first version. As for its portable device (iPod, iPhone and iPad), also on the OTT TV Apple TV relies on a proprietary integrated hardware + software (iTunes) + pre-selected library of content (iTunes Store).

3.5 Digital Dividend (Spectrum)

In the Radio Spectrum Policy Programme (RSPP) the Member States and the European Parliament decided to mandate the opening up of the 800 MHz throughout the EU by 1 January 2013, on the basis of the conditions of se specified in the existing EC Decision to harmonise the 800 MHz band.

By 1 January 2013, Member States shall carry out the authorisation process in order to allow the use of the 800 MHz band for electronic communications services.

Many European countries have already conducted the auctions for the 800 band in order to make available such band for broadband mobile services.

SWEDEN

Swedish telecommunications regulator PTS has announced that the auction of 800MHz (Digital Dividend) spectrum raised a total of SEK 2.054 billion (EUR 233 million), with three existing operators winning spectrum rights. The licences for a 25 year period went to TeliaSonera, 3 Sweden and Tele2 Sweden.

TeliaSonera said it will use its 2x10MHz blocks of 800MHz spectrum to further expand its 4G network. 3 Sweden also received 2x10MHz blocks as did Tele2 Sweden through the network company Net4Mobility.

Tele2 Sweden will use its frequencies to the roll-out of a 4G network. Com Hem and Netett Sverige also participated in the auction but did not win any licences

FRANCE

French telecommunication regulator Arcep received four applications for LTE/4G licences in the 800MHz band. The authority already awarded 2.6GHz LTE licences to the same bidders, Orange France, Free Mobile, SFR and Bouygues Telecom, for EUR 936 million. The new allocation of 800MHz spectrum, which came from the 'digital dividend', is a separate procedure. French telecom regulator Arcep has allocated the 800MHz “Digital dividend” spectrum for 4G mobile services to operators Bouygues Telecom, Orange France and SFR.

SFR won two blocks B&C of the 800MHz spectrum. Orange France, won block D, and Bouygues Telecom, won Block A. Each block is a 10 MHz duplex. Arcep will deliver authorisations to use the 800MHz frequencies in early January.

ITALY

Italy has raised €3.9 billion in its auction of 4G radio frequencies, more than double the reserve price of € 1.7 billion for 240MHz of spectrum.

Vodafone Italia acquired two blocks in the 800MHz band for a total € 992.4 million, as well as one block in the 1800MHz band for € 159.1 million. It also took three lots of FDD spectrum in the 2.6GHz band for € 36.06 million each. Vodafone said it will use the spectrum to launch LTE services, drawing on the experience of its sister company Vodafone Germany, which launched LTE at the end of 2010.

Telecom Italia acquired two 800MHz blocks for a total € 992.2 million and one 1800MHz lot for € 159.0 million, plus three lots of FDD spectrum in the 2.6GHz band for a total € 109.1 million.

Wind took two blocks in the 800MHz band for a total € 977.7 million, but missed out on the third block in the 1800MHz band, which went to 3 Italia for € 158.9 million. Wind also acquired four lots of the FDD spectrum in the 2.6GHz band, for a total € 142.2 million.

3 Italia also took the two TDD blocks in the 2.6GHz band for € 74.0 million and two lots of FDD spectrum in the 2.6GHz band for € 72.4 million, giving it a total 60 MHz or 25% percent of all spectrum allocated. The operator said it will start LTE trials in the coming months.

The operators will gain access to the 1800MHz band by the end of 2011, the 2.6GHz band by the end of 2012, and the 800MHz band at the start of 2013, after it's vacated by broadcasters. The licences for both bands run until 2029.

UK

In 2011 Ofcom has opened a consultation on proposals for the allocation of spectrum in the 800 MHz and 2.6 GHz band. These frequencies will be used to deliver future 4G services such as WIMAX and LTE as well as other broadband services.

This consultation is about how Ofcom should award this new spectrum in a way that secures the best use for the benefit of citizens and consumers. The award of the 800 MHz and 2.6 GHz bands was referred to in the Government's Direction to Ofcom made in December 2010 (the Direction). The Direction requires Ofcom to;

- Assess likely future competition in markets for the provision of mobile electronic communication services after the conclusion of the award of 800 MHz and 2.6 GHz bands.

- Hold an auction of the 800 MHz and 2.6 GHz bands as soon as reasonably practicable after concluding the competition assessment.

- Revise the annual licence fees paid for 900 MHz and 1800 MHz to reflect full market value having particular regard to the sums bid for licences in the 800 MHz and 2.6 GHz auction.

Further documents will follow as part of the preparations for the award. These will cover specific technical issues, in particular our proposals for technical conditions to manage the risk of interference into uses that are adjacent to the 800 MHz and 2.6 GHz bands including Digital Terrestrial Television (DTT).

Ofcom plans to publish the license regulations and begin the auctions in the first quarter of 2012.

GERMANY

The Telecom operators T-Mobile, Vodafone and Telefonica O2 have all been issued licences for their own 20MHz chunk of the 800MHz band, following auctions of the ‘digital dividend’. The ‘digital dividend’ is the spectrum released following the switch of TV services in Germany from analogue to digital. The spectrum will be used for the roll-out of mobile broadband services.

At the same time spectrum in the 1.8, 2.0 and 2.6 GHz bands was also auctioned.

Before the 800MHz band can be fully utilised, TV services using the same spectrum in nearby countries must be moved out of the band. This should happen by the end of 2012 in line with European Commission plan.

SPAIN

On July 29, 2011 in Spain the auction for the allocation of so-called Digital Divide was concluded The revenues generated from the auction totaled € 1.647 billion to which would add another € 168 million for the frequencies allocated by beauty contest in May 2011. In total this is therefore € 1,815 million. The auction involved 58 blocks of frequencies for a total of 270 MHz. More specifically, the number of national blocks was 2 in the 900 MHz national blocks, 50 blocks in the 2.6 GHz band (39 to 11 for local use and domestic use) and 6 blocks in the more "valuable" band, the 800 MHz. However, because they have been allocated only 51 of the 58 blocks planned, a further auction of unassigned licenses will be launched.

Considering the revenues generated from the auction and beauty contest, as well as that estimated for blocks not yet assigned, the total revenue could exceed € 2 billion The main beneficiaries of the allocation process were the three main mobile operators in Spain, namely Telefonica, Vodafone and France Telecom, which together have spent almost 99% of the total generated by the auction (€ 1,647 million) and gained a total of 190 MHz . The same three players are the only beneficiaries of spectrum in 800 MHz band, for which they have spent just over € 1.3 billion.

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