FUSE report

The battle for the digital dividend spectrum

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Abstract:

The digital dividend discussion represents an obvious conflict of interest between on the one hand the traditional broadcasters and on the other hand market players from other communication sectors. A conflict in accessing to the valuable spectrum resources that has been there for many years and which has been intensified in different phases of technological development. The report gives an analysis of the digital dividend and discusses relevant new applications, technology and the policy/regulatory issues at European and national level.

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Background

In summer 2008 the Strategic research council funded a research project (FUSE) to identify the relevant innovative services and applications to be used in the digital dividend spectrum. The aim was to come up with ideas for applications for the digital dividend spectrum in the 800 MHz band (792MHz – 862 MHz) as well as the VHF band.

The aim of this research is to point at and analyze alternative applications of the freed frequencies especially with respect to the frequencies in the so-called innovation reserve (MUX 7 and 8). The fact that we cannot escape the controversies between broadcasters and the communication sector has become very clear with the recent Danish decision by the ministers of culture and science and the policy partners in Parliament that the frequencies in the 790-862 band. i.e. basically MUX 7, should be allocated for mobile broadband. The primary reasons stated are that this will facilitate broadband coverage to all parts of the country and provide more frequencies for a high-demand area, but the basis is also that this is the way, for instance, Sweden has gone, and this is also in line with EU decisions on the matter. The EU policy is to allocate frequencies in the 790-862 MHz area to mobile broadband on a technology and service neutral basis, i.e. without any foregone policy decisions on the use, including 'alternative use'.

Introduction

The objective of this report is to identify the relevant uses of digital dividend spectrum. The digital dividend discussion represents an obvious conflict of interest between on the one hand the traditional broadcasters and on the other hand market players from other communication sectors. A conflict in accessing to the valuable spectrum resources that has been there for many years and which has been intensified in different phases of technological development. The report gives an analysis of the digital dividend and discusses relevant new applications, technology and the policy/regulatory issues at European and national level.

The market organisation of radio and TV broadcast services has historically been dominated by either monopoly organisation (national or local) or in few cases by markets having few competing broadcasters. The spectrum scarcity argument has been used as one of the reasons for this market organisation model and for not giving resources to other communication sectors. However, the scarcity argument was challenged from the beginning[1].

In the US, for example, the strong broadcasters began to market HDTV at the end of 1980s to replace NTSC[2] trying to hold on the extra TV channels allotted for television services in every city[3]. This resulted in FCC's provision of spectrum without cost to virtually all of the current television broadcasters to provide for parallel transmission of 'advanced television services'[4] in the 1996 Telecommunication Act. This raised huge resistance from other market actors who were interested in the spectrum, especially, the actors from the "land mobile" and computer industry. In the recent years substantial part of the 'TV spectrum' is released for other uses[5].

So the spectrum war and the battle between broadcasters and other market players on the allocated broadcast spectrum is not a new thing. The new thing is, as mentioned, the implications of the transition from Analogue to digital and the determined deadlines for 'analogue shut down' in virtually all advanced markets.

The digital transition radically changes the spectrum situation. Depending on different technological parameters a spectrum efficiency of 6 to 8 times can be achieved when we go from analogue to digital. The question is then if all the new spectrum resources should go to TV broadcast or we should use part of it for other services, e.g., mobile broadband services.

While Digital Dividend may have a broader meaning in ICT for development relating to developing economies, the term refers to the radio frequencies that are being set free in relation to the switch-over from analog to digital broadcasting in the developed economies (Europe, etc.). The EU defines the Digital Dividend as 'the spectrum over and above the frequencies required to support existing broadcasting services in a fully digital environment, including current public service obligations' (COM/2007) 700 final).

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[1] See among others Coase R. :"The federal Communication Commission", The journal of Law & Economics, October 1959 and (Noam 1991)

[2] This was a lobbying strategy against Land Mobile. By the end of the 1980s, actors from "Land Mobile" industries applied for these resources to use them for mobile communication systems. Broadcasters, led by the National Association of Broadcasters (NAB), came up with the argument that they needed these resources to introduce HDTV.

[3] In Washington, e.g., networks and independent stations broadcast on channels 4, 5, 7, and 9 on the VHF and 20, 26, 32 and 50 on UHF. The rest of the designated broadcast TV channels, 2 through 69, were vacant and the situation was similar in every city

[4] Later Digital HDTV services

[5] Se more more details later in this paper.

The issues relating to the Digital Dividend are dealt with in a range of different international and national organizations and settings. ITU and its Radio Conferences are crucial events. There is often reference to ITU's Regional Radiocommunication Conference in Geneva in 2006 (RE-06), which took some decisions regarding the distribution of the Digital Dividend between the different applications, primarily broadcasting and interactive communications (e.g. mobile broadband). These decisions have become subject to some criticism especially by the EU Commission as they somehow run counter to manner in which the EU plans to 'clean up' the Digital Dividend by dividing it up into three clusters (high-powered broadcasting, lower-powered broadcasting, for instance mobile TV, and low-powered interactive mobile communications). Furthermore, RE-06 gave more emphasis to broadcasting than the present policies of the EU Commission.

The EU is, as mentioned, also very active in influencing the use of the Digital Dividend. The document mentioned (COM(2007) 700 final) is a crucial policy statement in this context, and the EU is very active in the field with its Radio Spectrum Policy Group (RSPG) and its political foundation in the Wireless Access Policy for Electronic Communications Services (WAPECS). The EU ambitions are basically to promote a harmonized market in the EU and, therefore, harmonized decisions with respect to spectrum usage, and to implement a technology and service neutral policy and spectrum trading. These general policy directions heavily influence the decisions taken by the different Member States. And, the EU is still working very much on the matter. The EU commissioned a major work to Analysys Mason (Mason 2009). This work is a centerpiece in the future directions for EU policies.

The main controversy or dividing line runs between broadcast use and mobile communications. The broadcasters of Europe and especially the public service broadcasters are very active in promoting the use of the freed resources for new broadcast applications, e.g. new channels and High Definition TV. Examples of these activities can be seen in EBU's view on 'How should the digital dividend be used?' (EBU, 2008) and 'Nordic public service broadcasters comments to the RSPG opinion on EU spectrum policy implications of the digital dividend' (Nordic PSB, 2006). Their focus is on media pluralism and cultural diversity and they believe that this can best be promoted by allocating a large part of the frequencies to new broadcasting possibilities. A characteristic statement is the one on the front page of the abovementioned EBU documents, where it reads 'Long-term Public interest versus short-term profit'. An organization where the broadcasters' point of view have found following is, for instance, the Council of Europe (2008).

On the other side, one finds the mobile operators wanting to use the frequencies for extended and improved mobile broadband. There is presently a huge demand for mobile broadband. This is one of the growth areas of the telecommunications industry, and there are also sound economic arguments for allocating a large part of the frequencies for mobile broadband. This is, for instance, substantiated in a report written by Forge, Blackman and Bohlin (2007) – a report commissioned by T-mobile International. There are surely vested interests at play in this context, but the results are not much different from what we arrived at some years ago when making a similar comparison of the economic value of mobile communications as opposed to broadcasting (see amongst others (Falch & Tadayoni 2004). The economic value added of mobile (broadband) communications is larger than for broadcasting. This is probably also recognized by the broadcasting community, as their emphasis and arguments relate to cultural long-term interests as opposed to 'short-term profits'.

The above mentioned Masson analysis gives the most comprehensive discussion of the issue and points to a number of different deployment scenarios. Also on la-rete.net (http://www.la-rete.net) – an Italian site/organization dealing with the Digital Dividend, there is a comprehensive overview. On this site, Martin Cave (2008) has a small piece on the situation in the UK, where he lists the following uses and applications:

- mobile television and other types of mobile video and multimedia;
- extending existing DTT coverage;
- new DTT channels aimed at a UK market in either SD or HD;
- new DTT channels aimed at local markets (i.e. local television);

- wireless microphones and applications for PMSE;
- other low power applications, like hubs to distribute content around the home or using ultra wideband (UWB) technologies;
- broadband wireless applications, which could be mobile, and other mobile voice and data services;
- services using satellite communications;
- emergency and public safety services;
- community radio;
- digital radio;
- communication with medical professionals and educational institutions;
- amateur and/or university use;
- new services for people with disabilities;
- international and cross border uses (e.g. an international emergency channel);
- digital public service teletext to match the analogue service; and
- user created networks (e.g. employing mesh technology).

One of the most promising new applications could be in the public safety and security (PSS) area. WIK and Aegis has made a larger report in this area – commissioned by EADS and Motorola: 'Safety First – Reinventing the Digital Divide in Safeguarding Citizens (WIK & Aegis, 2008). The PSS is further discussed in details in the case studies in this report

The analysis is based on review of 'research projects' and 'political documents' and country case studies. Furthermore a number of interviews with the relevant stakeholders in Denmark are conducted.

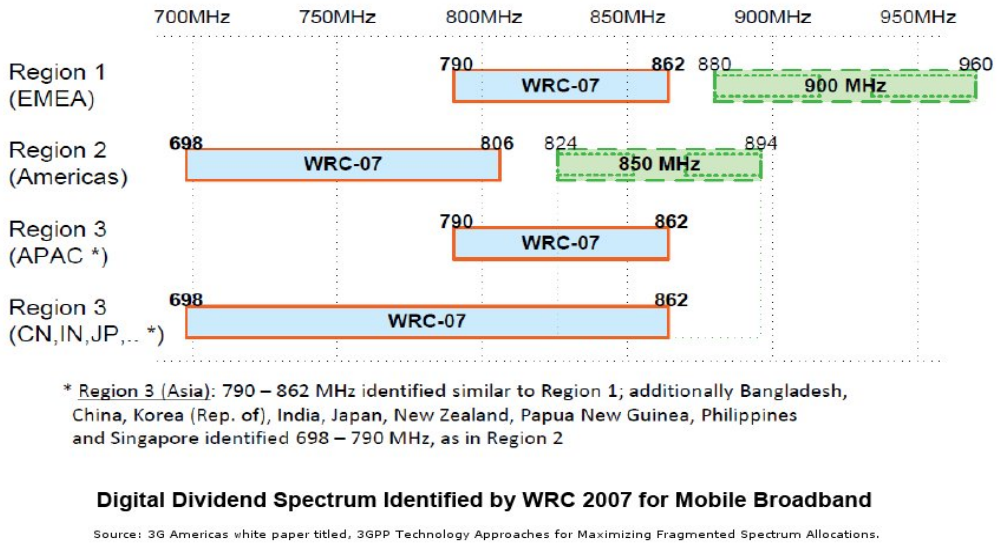
Country case studies

3 US

1.1 Market overview

Outside of Europe, the majority of countries have not set up a concrete plan for how to use and allocate the digital dividend spectrum. The U.S. is leading the way in freeing up and allocating digital dividend spectrum.

Figure 1. WRC-07 Results for UHF band



Source: Impact of WRC-07 and the U.S. Implementation of the Digital Dividend, April 3, 2008

In 2003, the FCC ordered analog television broadcasters in channels 52-69 (698-806 MHz) to vacate and to only operate DTV in channels 2-51(500-600 MHz). In 2006, the DTV Act set a firm deadline for the end of the DTV transition of February 17, 2009, at which time the spectrum in the 700 MHz Band, occupied by television broadcasters in TV Channels 52-69, would become available for wireless services, including public safety and commercial services. As part of the transition of TV services to digital television (DTV), broadcasters are being moved from Channels 60-69 and Channels 52-59 to assignments below Channel 52. These actions will make this spectrum – 60 MHz of spectrum referred to as the "Upper 700 MHz Band" and 48 MHz referred to as the "Lower 700 MHz Band" – available for new services. Congress has mandated that 24 MHz of the Upper 700 MHz Band be reallocated to public safety services, and that the remaining 700 MHz spectrum be auctioned[6].

On February 11, 2009, with enactment of the DTV Delay Act, the DTV transition deadline was extended from February 17, 2009, to June 12, 2009.

The final switchover to digital TV occurred on 12 June 2009 but the regulator completed the auction of spectrum in the 700 MHz band already in March 2008, and distributed the spectrum to a variety of

[6] 700 MHz First Report and Order, 22 FCC Rcd at 8066 ¶ 2.

providers mainly via a technology-neutral approach. Therefore it is expected that the winning operators will launch commercial services on the released spectrum in 2010.

1.2 Digital Dividend

700 MHz Band.

According to FCC, the 700 MHz band is a critical resource for wireless broadband services in particular because of its superior propagation characteristics, building penetration capability, and suitability for mobile applications. In orders adopted in December 2001 and October 2003, the Commission completed rulemakings to reallocate the non-public safety portion of the "upper" 700 MHz Band and the entire "lower" 700 MHz Band to new fixed and mobile services for a broad range of flexible uses.[7] As these channels are cleared of incumbent broadcasters, prime spectrum becomes available for uses ranging from the implementation of next generation applications and extensions of existing mobile and fixed networks to the implementation of various innovative stand-alone technologies and services. Also, because the band is situated near spectrum currently licensed to cellular and other CMRS services, this allocation creates efficiencies for carriers and manufacturers in designing new products and networks that would benefit consumers.

The blocks are paired up to facilitate better cellular communications by allocating a bandwidth per block. Pairing the blocks gives cellular network companies the ability to utilize separate frequencies for up-linking and down-linking, which better utilizes the limited frequency spectrum and provides more reliable communications. The exception to this is block C, which is unpaired because it uses the largest bandwidth range, 22 MHz, and is able to support robust frequency engineering and frequency reuse on its own.

Lower 700 MHz[8] (698-746 MHz)

Lower 700 MHZ has 5 blocks (38 MHz): A - E. The A, B, and C blocks are paired, which makes them useful for services that require two-way transmission. The D and E blocks are unpaired, thus they only support one-way transmission (ideal for one-way broadcasting – Qualcomm MediaFLO).

A licensee on the Lower 700 MHz Band is permitted to provide fixed, mobile, and broadcast services. Possible uses of this spectrum include digital mobile and other new broadcast operations, fixed and mobile wireless commercial services (including FDD- and TDD-based services), as well as fixed and mobile wireless uses for private, and internal radio needs.

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[7] *See* Service Rules for 746-764 and 776-794 MHz Bands, and Revisions to Part 27 of the Commission's Rules, Carriage of the Transmissions of Digital Television Broadcast Stations, Review of the Commission's Rules and Policies Affecting the Conversion to Digital Television, *Third Report and Order*, 16 FCC Rcd 2703 (2001); Service Rules for 746-764 and 776-794 MHz Bands, and Revisions to Part 27 of the Commission's Rules, Carriage of the Transmissions of Digital Television Broadcast Stations, Review of the Commission's Rules and Policies Affecting the Conversion to Digital Television, *Order on Reconsideration of the Third Report and Order*, 16 FCC Rcd 21633 (2001); Reallocation and Service Rules for the 698-746 MHz Spectrum Band (Television Channels 52-59), *Report and Order*, 17 FCC Rcd 1022 (2001); Service Rules for 746-764 and 776-794 MHz Bands, and Revisions to Part 27 of the Commission's Rules, Carriage of the Transmissions of Digital Television Broadcast Stations, Review of the Commission's Rules and Policies Affecting the Conversion to Digital Television, *Second Order on Reconsideration of the Third Report and Order*, 18 FCC Rcd 23308 (2003).

[8] http://wireless.fcc.gov/services/index.htm?job=about&id=lower700

The rules governing the Lower 700 MHz Band are generally found in the 47 CFR Part 1 and Part 27. (http://wireless.fcc.gov/services/index.htm?job=about&id=lower700)

Upper 700 MHz (746-806 MHz)

The upper band is divided into five paired blocks; with A through D being auctioned for commercial use and the fifth being devoted to communication related to public safety.

Blocks A and B were originally guard bands on either side of the public safety blocks, which meant that they had to conform to strict standards on reducing interference on neighboring frequencies. They were also not allowed to use a cell-based architecture. After a restructuring, however, only the B block is subject to these requirements[9]. Both of these blocks are licensed by Major Economic Areas (MEAs), of which there are 51[10]. 700 MHz Guard Bands spectrum can be used for fixed and mobile services. Spectrum can be leased to commercial service providers or directly to end users. [11]

Guard Bands licensees can act as system operators, or can lease their spectrum to system operators or directly to end users through the Commission's Secondary Markets spectrum leasing policies and rules.

Block C consists of paired 11 MHz blocks, giving it the largest bandwidth of any group up for auction. In addition, it is licensed as only twelve Regional Economic Area Groupings (REAGs), six of which combine to cover the entire continental United States; the other six are for Alaska, Hawaii, and outlying U.S. territories. For the C Block, the FCC created special open access provisions:

- ✓ Open devices so consumers can use a handset with any wireless network operator
- ✓ Open applications so consumers can download and use any software applications, content, or services they desire without "walled gardens,"[12]

Licensees may not "lock" handsets to prevent their transfer from one system to another, or to other services that compete with wireless service providers' own offerings.

Block D consists of paired 5 MHz blocks and only one nationwide license is being given for the entire block. All devices on this part of the band must support spectrum sharing with the public safety devices, as part of the 700 MHz Public/Private Partnership. In this sense, Block D acts somewhat as a guard between itself and the frequencies devoted solely to public safety[13].

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[9] Adam LaMore, The 700 MHz Band: Recent Developments and Future Plans, April 2008

[10] http://wireless.fcc.gov/auctions/data/maps/mea_basic.pdf

[11] http://wireless.fcc.gov/services/index.htm?job=service_home&id=700_guard

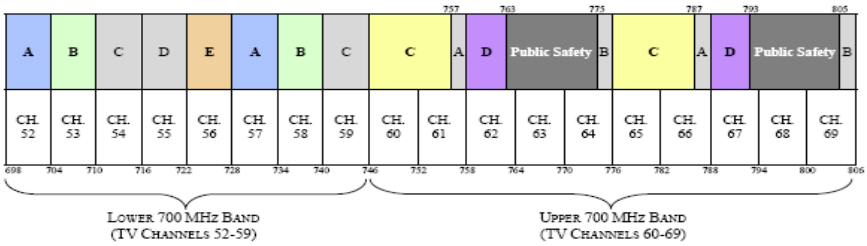
[12] but not the open services and open networks principles.

[13] "Second Report and Order, FCC 07-132", 10 August 2007,

http://wireless.fcc.gov/auctions/default.htm?job=release&id=3457&y=2007.

Figure 1. Revised 700 MHz Band Plan for Commercial Services

Revised 700 MHz Band Plan for Commercial Services



Block	Frequencies (MHz)	Bandwidth	Pairing	Area Type	Licenses
A	698-704, 728-734	12 MHz	2 x 6 MHz	EA	176
B	704-710, 734-740	12 MHz	2 x 6 MHz	CMA	734
C	710-716, 740-746	12 MHz	2 x 6 MHz	CMA	734
D	716-722	6 MHz	unpaired	EAG	6
E	722-728	6 MHz	unpaired	EA	176
C	746-757, 776-787	22 MHz	2 x 11 MHz	REAG	12
A	757-758, 787-788	2 MHz	2 x 1 MHz	MEA	52
D	758-763, 788-793	10 MHz	2 x 5 MHz	Nationwide	1 *
B	775-776, 805-806	2 MHz	2 x 1 MHz	MEA	52

* Subject to conditions respecting a public/private partnership.

The blocks shaded above in gray (Lower 700 MHz Band C and D Blocks and Upper 700 MHz Band A and B Blocks) were auctioned prior to Auction 73.

Source: FCC, Band Plans, updated 9/5/2007,

http://wireless.fcc.gov/auctions/default.htm?job=bandplans

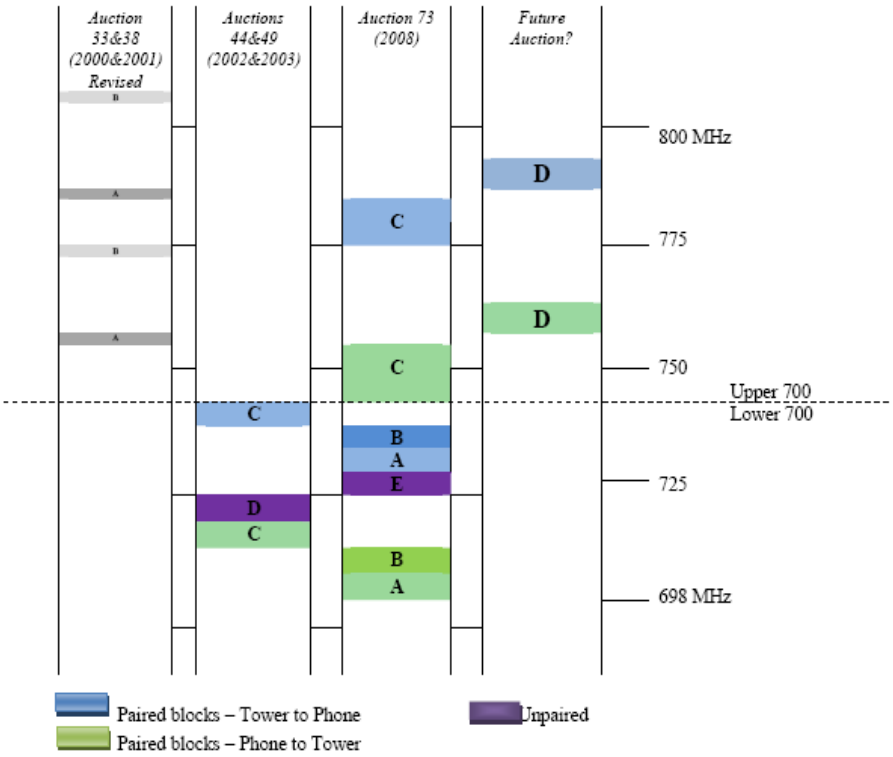
The 700 MHz auction

Since 1994, the US Federal Communications Commission has conducted 82 auctions of radio-frequency spectrum. Of these, 14 have been for microwave spectrum (above 1,000 MHz), which can be used for fixed and mobile broadband services.

The largest auction was the Commission's auction of 700 MHz band licenses (Auction 73) that closed on March 18. This auction included a mix of blocks from Upper 700 and Lower 700 MHz bands including the lower A, B, and E blocks as well as the upper C and D blocks.

Prior to the Auction 73, there were Auctions 44 and 49 included the lower 700 MHz blocks C and D. The upper guard bands (blocks A and B) were auctioned off during FCC Auctions 33 and 38.

Figure 2 700MHz Blocks by Auction



As a result of auction 73, a diverse mix of new entrants and small regional and rural providers as well as nationwide providers succeeded in acquiring access to spectrum needed to deploy the next generation of wireless networks.

It is important to point out that Advanced Wireless Services band is not only divided by blocks but also geographically, and geographic divisions are not the same for each block. The size of the geographic service areas for the 700 MHz Band have been divided into a combination of large, regional Economic Area Groupings ("EAGs") and smaller Cellular Market Areas (CMAs) composed of Metropolitan Statistical Areas ("MSAs") and Rural Service Areas ("RSAs").

Figure 3. Geographic division and block winner

Geographic division	Block winners
A block / 12 MHz (Lower 700 MHz - Auction 73)	
Build out requirements: 35% of geography by 2013; 70% by 2019 **A block is divided geographically into Economic Areas (EAs) which are the medium size geographic divisions – 176**	**Verizon – 25 licenses** **US Cellular – 25 licenses** **Cavalier – 23 licenses** **Century Tel – 21 licenses** **Cell South - 14 licenses** **Cox - 14 licenses** **Continuum – 20 licenses** **LL License – 5 licenses** **Triad – 4 licenses** **Miller – 3 licenses** **Other Less than 3 wins**
B block / 12 MHz (Lower 700 MHz - Auction 73)	
Build out requirements: 35% of geography by 2013; 70% by 2019 **Lower B block is divided up by CMAs Cellular Market Areas[14] of which there are 734.** **The CMAs are further divided into 429 Rural Service Areas (RSAs)[15] and 305 Metropolitan Statistical Areas (MSAs)[16] to fulfill two different requirements.**	**AT &T – 227 licenses** **US Cellular – 127 licenses** **Verizon – 77 licenses** **Century Tel – 48 licenses** **Triad – 30 licenses** **Miller – 30 licenses** **Cavalier – 12 licenses** **Cell South - 10 licenses** **Broadband – 9 licenses**

[14] The CMAs are the areas' most likely to utilize the Universal Services Fund (USF) if the FCC decides to extend the definition to include cellular communications.

[15] The RSAs allow rural locations to provide cheaper services because the specialized, local service can focus on just that market.

[16] The MSAs serve the heavier populated areas, supporting integrated services across a specialized area.

	Cox - 8 licenses **PCS Partner ¬– 8 licenses** **Other Less than 8 wins**
C block / 22 MHz (Upper 700 MHz - Auction 73)	
Build out requirements: 40% of population of each EA in each REAG by 2013; 75% by 2019 **22 MHz bandwidth (746–757 and 776–787 MHz) – 12 regional groups**	**Verizon – 7 licenses** **Triad – 7 licenses covering Alaska, Puerto** **Small Vent – 1 license**
D Block / 10 Mhz (Upper 700 MHz - Auction 73)	
Build out requirements: 75% of population by 2013; 95% by 2016; 99,3% by 2019 **5 MHz paired – one Nationwide License (subject to Public/Private Partnership conditions)**	**Re-auctioning soon to be clarified**
E Block / 6 MHz unpaired spectrum (Lower 700 MHz - Auction 73)	
Build out requirements: 35% of geography by 2013; 70% by 2019 **E Block is divided into 176 EAs**	**Frontiers – 168 licenses** **Qualcomm – 5 licenses** **Chevron US - 1 license** **Kurian – 1 license**

Auction 73 concluded with 1090 provisionally winning bids covering 1091 licenses and totaling $19,592,420,000. The provisionally winning bids for the A, B, C, and E Block licenses exceeded the aggregate reserve prices for those blocks. The provisionally winning bid for the D Block license, however, did not meet the applicable reserve price and thus did not become a winning bid[17].

Build-Out Requirements

The FCC adopted

- ✓ **geographic area build-out requirements** (35 percent of the area within four years and 70 percent within 10 years) for the **Lower 700 MHz** blocks
- ✓ and **population based build-out requirements** (40 percent within four years and 75 percent within 10 years) for the **Upper 700** MHz blocks.

[17] http://wireless.fcc.gov/auctions/default.htm?job=auction_summary&id=73

If the build-out requirements are not met, the areas not built out will be forfeited. Very strict build-out requirements (99.3 percent of the population to be covered within 10 years) were adopted for Upper 700 MHz Block D, which is the block that will be shared with public safety.

1.3 Future plans

Verizon

Verizon announced (in 2008) that it would use its purchases in **the upper C block** as well as the **lower A and B blocks** to deploy an **LTE-**compatible network. They estimate that this network will be rolled out in 2010 [Verizon].

Verizon plans to make LTE a bridge between its FiOS[18] broadband network and traditional mobile services and as recently as CTIA Wireless, Verizon Business began pushing services beyond the enterprise into the mobile footprint. Its open access developer program will create mobile business cases for myriad currently unconnected electronic devices as well as integrate connectivity into appliances, cars and homes. Instead of shooting for 100% penetration of mobile phones, Verizon can now aim for multiple wireless date connections for each person[19].

AT&T

AT&T announced (in 2008) that they would be using their 700 MHz licenses to create an **LTE** network, though they estimate completion in 2012.

AT&T owns a 700 MHz very similar to Verizon's due to its acquisition of Aloha Partners. Aloha owned most of the licenses in the lower C block sold in Auctions 44 and 49 before the open-access requirements were impose. In Auction 73, AT&T won parts of the lower B block. This leaves them with 12 or 24 MHz of bandwidth in most major markets, though there is still a large amount of relatively less populated areas where they do not have any licenses, thus preventing them from building a nationwide network comparable to the one Verizon will be building [Brome].

Frontier Wireless (Echostar)

Frontier Wireless a partner of U.S. satellite television company EchoStar won E" block spectrum auction covering almost all of the United States.

Frontier Wireless has not indicated what it will do with its new spectrum – perhaps a MediaFlo-like portable or mobile video system or a terrestrial mechanism for providing standard definition local-into-local programming[20].

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[18] Verizon FiOS is a bundled communications (Internet, telephone, and TV) service, operating over a fiber-optic communications network, that is presently offered in some areas of the United States by Verizon. Verizon has attracted consumer and media attention in the area of broadband Internet access as the first major U.S. carrier to offer fiber to the home/premises. Other service providers currently only use fiber optics deployment to the network backbone and use existing copper or coax infrastructure for the end user. The coverage area is still expanding; however, some areas do not have service or cannot receive TV and phone service because of franchise agreements.

[19] http://connectedplanetonline.com/wireless/news/winners-700-mhz-plans-0404/

[20] How much Digital Dividend? - How countries tackle the question?, ITU BDT Seminar Transition from Analogue to Digital Broadcasting: correlation between technical, economic and social costs and advantages, 16 - 18 June 2009, Saransk, Russian Federation, Pham Nhu Hai Head, Broadcasting Services Division

Qualcomm

Qualcomm plans to use licenses it bought in the **E block** to provide more capacity for its mobile broadcast TV service MediaFlo. The E-block licenses will expand **MediaFlo** coverage in areas such as Boston, Los Angeles, New York City, Philadelphia, and San Francisco.

The **B-block** licenses, which cover parts of California and New Jersey, will be used for **research and development.**[21]

Figure 4, Summary of Top 4 Winners by Net Winning Bids

Rank	Bidder	Number of PWBs	Total Net PWB Amount	Breakdown of winnings
1	Verizon Wireless	109	$9,363,160,000	7 C block covering 98% of pops 25 A block covering 52% of pops 77 B block covering 16% of pops
2	AT&T	227	$6,636,658,000	227 B block covering 62% of pops
3	Echostar (Frontier Wireless)	168	$711,871,000	168 E block covering 76% of pops
4	Qualcomm	8	$558,142,000	5 E block covering 24% of pops 3 B block covering 0.1% of pops

Source: http://wirelessstrategy.com/700auction.html

Public Safety Spectrum[22]

VHF high band is by far the most deployed public safety band in the US and most of the agencies would like to continue its use in low density rural population areas where better propagation supports lower cost deployments. 700 MHz and 800 MHz are needed for more densely populated urban areas requiring more capacity and less range and coverage per site.

Historically, the total amount of spectrum for public safety in the U.S. has been 23.1 MHz in the VHF, UHF, and the 800 MHz bands plus a few other little used bands. The 800 MHz band has experienced significant interference problems and is being re-banded to move public safety users from fragmented assignments to frequencies better separated from other users[23].

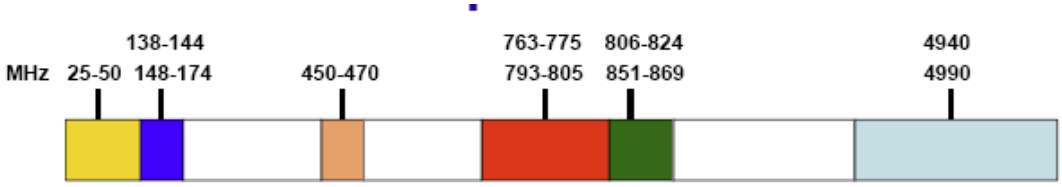
Figure 2, Public Safety Land Mobile Radio Spectrum Bands

Radiocommunication Bureau, http://www.itu.int/ITU-D/tech/digital-broadcasting/SaranskJune2009/Presentations/Day3/Saransk_June2009_Day3_3.pdf

[21] Marguerite Reardon, Bidders in latest FCC auction start talking, April 3, 2008

[22] http://www.fcc.gov/pshs/public-safety-spectrum/700-MHz/

[23] Public Safety Spectrum Allocation Bandwidth and Density of Re-Use, Ron Haraseth, Director, Automated Frequency Coordination, APCO International



Allocation	MHz
✓ VHF Low Band (25-50 MHz)	6.3
✓ VHF High Band (138-144/148-174)	3.6
✓ UHF Band (450-470 MHz)	3.7
✓ 800 Band (806-821/851-866 MHz)	3.5
✓ 800 Band (821-824/866-869 MHz)	6.0
✓ **700 Band (763-768/793-798 MHz) Broadband Data**	**10.0**
✓ **700 Band (768-769/798-799 MHz) Guardband**	**2.0**
✓ **700 Band (769-775/799-805 MHz) Narrowband Voice**	**12.0**
TOTAL	**47.1**
This does not include 470/512 MHz spectrum used in 11 of the largest US Cities	
4 GHz Band (4940-4990 GHz)	50.0
Because of its propagation, this spectrum is only practical for local	
area networks and hot spots – not for wide area or mobile networks	

Source: Public Safety Radio Communications, wireless broadband is not an alternative to LMR mission critical voice systems, Chief Harlin R. McEwen, Chairman, Communications & Technology Committee International Association of Chiefs of Police, 10/12/09

New public safety 700 MHz band allocations (shown in Figure 3) that total 24 MHz will almost double public safety allocations.

The FCC reorganized the public safety spectrum to establish one narrowband block and one broadband block. The broadband block will be licensed on a nationwide basis to a non-commercial, not-for-profit entity that would manage an interoperable network for all public safety users nationwide. Commercial Upper 700 MHz Block D (with 10 MHz of paired spectrum) will be adjacent to the public safety broadband block.

Block D will be licensed on a nationwide basis, with the auction winner being required to enter into a partnership with the public safety broadband licensee to build out a network to be shared by the public safety licensee and the Block D auction winner.[24]

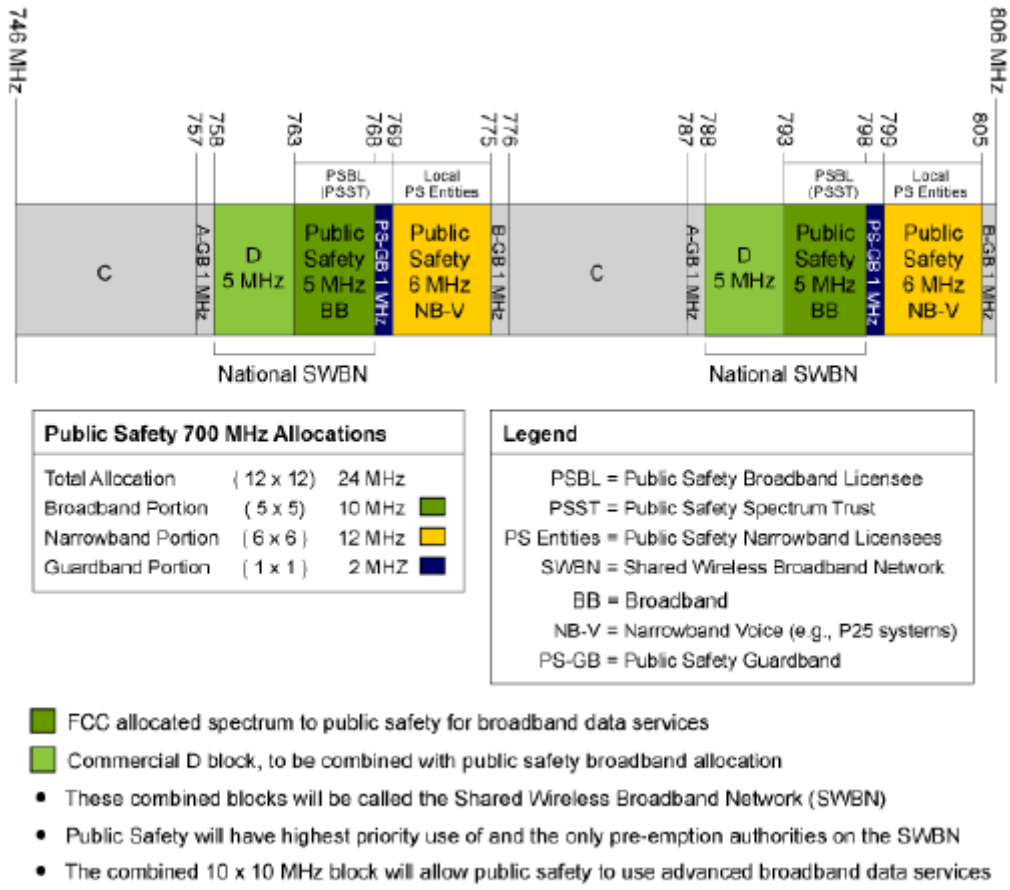
The FCC has mandated that the D-Block licensee will be responsible for building out a national public safety network with 75% population coverage within four years of getting the license, and 95% of the U.S. population by the end of the seventh year, and 99.3% of the U.S. population by the end of the tenth year[25].

[24] http://www.bingham.com/Media.aspx?MediaID=5425

[25] Frontline estimated that the network would cost roughly $10 billion to build out, in addition to the $1.3 billion or more the company would have to pay for the spectrum rights. The high build-out costs combined with the FCC's stringent time requirements make it difficult for any company to feel enthused about bidding for the block.

D Block licensee(s) also must develop and offer devices that operate both on the D Block and the neighboring public safety broadband block, with a path toward scale production of components and devices that can utilize both blocks, in order to stimulate the public safety broadband equipment "ecosystem."

Figure 5. Public Safety Spectrum Allocation in the 700 MHz Band



Source: Public Safety/Commercial Shared Network, http://www.psst.org/networkbenefits.jsp, February 09, 2010

The D-Block failed to attract any qualifying bids of $1.3 billion and on March 20, 2008, the FCC issued an order delaying further D Block action until further notice[26].

In 2010, Federal regulators are proposing that Congress devote up to $16 billion over 10 years to pay for a nationwide wireless broadband network: $6 billion grant program to build the public safety network, plus a $6 billion to $10 billion grant program to operate and upgrade the network[27].

[26] The absence of meaningful bidding activity indicated that the public safety obligations as designed were not commercially viable.

There are currently no standards being developed to provide such a service. The public safety community has endorsed **Long Term Evolution (LTE)** as the **preferred broadband standard for public safety.**

Spectrum leasing arrangements

In two separate orders, adopted in May 2003 and July 2004, the Commission established policies and rules that permit parties to enter into a wide variety of spectrum leasing arrangements to enable them to access the amount of licensed spectrum they may need to provide service.[28]

The Commission adopted policies that permit immediate (*i.e.*, overnight) processing of certain qualifying spectrum leasing arrangements as well as certain qualifying transfers and assignments of licenses. The Commission also clarified that the spectrum leasing rules permit parties to enter a variety of "dynamic" leasing arrangements. Such arrangements, made increasingly possible by technological advances, enable licensees and spectrum lessees to enter into agreements to share use of the same licensed spectrum over the same period of time[29].

Band III (high-band VHF)

Band III ranges from 174 to 230 MHz, and it is primarily used for radio and TV broadcasting.

United States and Canada

Frequency assignments between US and Canadian users are closely coordinated since much of the Canadian population is within VHF radio range of the US border. Certain discrete frequencies are reserved for radio astronomy. The general services in the VHF band are:

- 30–46 MHz: Licensed 2-way land mobile communication.[2]
- 30–88 MHz: Military VHF-FM, including SINCGARS
- 43–50 MHz: Cordless telephones, 49 MHz FM walkie-talkies and radio controlled toys, and mixed 2-way mobile communication. The FM broadcast band originally operated here (42-50 MHz) before moving to 88-108 MHz.

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[27]Regulators Propose A Nationwide Wireless Broadband Network For Public Safety, 02.2010, http://news.smh.com.au/breaking-news-technology/regulators-propose-grant-program-for-public-safety-20100226-p684.html

[28] *See* Promoting Efficient Use of Spectrum Through Elimination of Barriers to the Development of Secondary Markets, *Report and Order and Further Notice of Proposed Rulemaking*, 18 FCC Rcd 20604 (2003) (*Secondary Markets First Report and Order*); Promoting Efficient Use of Spectrum Through Elimination of Barriers to the Development of Secondary Markets, *Second Report and Order, Order on Reconsideration, and Second Further Notice of Proposed Rulemaking,* 19 FCC Rcd 17503 (2004) (*Secondary Markets Second Report and Order*).

[29] For example, a carrier with a nationwide license can, without significant transaction costs, lease or sell spectrum to rural carriers to build networks in rural areas. Rural carriers thus have the potential to obtain spectrum and build networks suited to their particular geography, while at the same time enabling the national carrier to develop partners to fill out its service coverage areas. Spectrum leasing and transfers – along with partitioning and disaggregation – thus provide flexibility for the development of additional and innovative services in rural areas.

- 50–54 MHz: Amateur radio 6 meter band; 50 MHz is an amateur radio band used for a variety of uses including DXing, FM repeaters and radio control, which usually takes place on a "set-aside" band between 50.8 and 51 MHz.
- 55-72 and 77-88 MHz TV channels 2 through 6 (VHF-Lo), known as "Band I" internationally; a tiny number of DTV stations will appear here. See North American broadcast television frequencies
- 72–76 MHz: Radio controlled models, industrial remote control, and other devices. Model aircraft operate on 72 MHz while surface models operate on 75 MHz in the USA and Canada, air navigation beacons 74.8-75.2 MHz.
- 88–108 MHz: FM radio broadcasting (88–92 non-commercial, 92–108 commercial in the United States) (Known as "Band II" internationally)
- 108–118 MHz: Air navigation beacons VOR
- 118–137 MHz: Airband for air traffic control, AM, 121.5 MHz is emergency frequency
- 137-138 Space research, space operations, meteorological satellite [3]
- 138–144 MHz: Land mobile, auxiliary civil services, satellite, space research, and other miscellaneous services
- 144–148 MHz: Amateur radio band 2 Meters
- 148-150 Land mobile, fixed, satellite
- 150–156 MHz: "VHF Business band," the unlicensed Multi-Use Radio Service (MURS), and other 2-way land mobile, FM
- 156–158 MHz VHF Marine Radio; narrow band FM, 156.8 MHz (Channel 16) is the maritime emergency and contact frequency.
- 160-161 MHz Railways [4]
- 162.40–162.55: NOAA Weather Stations, narrowband FM
- 175-216 MHz television channels 7 - 13 (VHF-Hi), known as "Band III" internationally. A minority of DTV channels may appear here.
- 174–216 MHz: professional wireless microphones (low power, certain exact frequencies only)
- 216–222 MHz: land mobile, fixed, maritime mobile,[5]
- 222–225 MHz: 1.25 meters (US) (Canada 219-220, 222-225 MHz) Amateur radio
- 225 MHz and above: Military aircraft radio (225–400 MHz) AM, including HAVE QUICK, dGPS RTCM-104

The large technically and commercially valuable slice of the VHF spectrum taken up by television broadcasting has attracted the attention of many companies and governments recently, with the development of more efficient digital television broadcasting standards.

2. Japan

1.1 Market overview

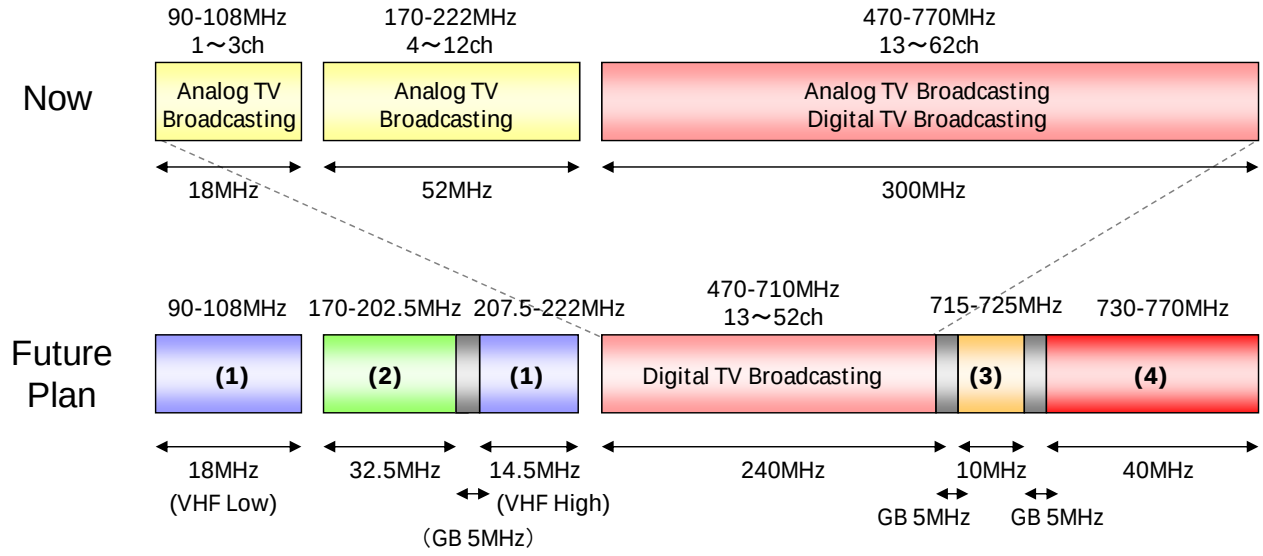
Digital broadcasting has already been operational in Japan since 2000. In satellite broadcasting, digital transmission began in 2000 and terrestrial digital broadcasting in 2003 with mobile phone service ("one-seg" broadcast) started in April 2006

1.2 Digital Dividend

In Japan, analog terrestrial TV broadcasting is scheduled to be terminated on July 24, 2011. At present, 370MHz bandwidth in VHF/UHF frequency bands are used by analog TV broadcasting and 300MHz bandwidth in UHF band within these bands is used by digital TV broadcasting. Due to the termination, a wide spectrum of 1-12 channels in VHF band (70 MHz bandwidth) and 53-62channels in UHF band (60 MHz bandwidth) will be vacant by 2011 and 2012, respectively.

Frequency bandwidth for terrestrial television will be reduced from 370MHz to 240MHz.

Figure 6. Digital dividend in Japan



(1) Non TV Broadcasting => e.g., Multimedia broadcasting for mobile receivers
(2) Private Telecommunication (Protection against disasters, etc)
(3) Intelligent Transport Systems
(4) Telecommunications

Schedule plan
(1) (2) after July 25, 2011
(3) (4) after July 25, 2012

Source: One-Seg & Mobile broadcasting, Masami Fujita, Japan Broadcasting Corporation (NHK), July 8, 2008

1.3 Future plans

VHF

90-108MHz – Digital radio broadcasting[30]

18MHz of spectrum in the VHF low band is assigned for **regional broadcasting**.

ISDB-Tsb (Integrated Services Digital Broadcasting Terrestrial for sound broadcasting)[31] standard has been adopted for regional broadcasting.

Test licences for ISDB-Tsb was awarded to DRP in 2003 and experimental ISDB-Tsb services started at 10th Oct. 2003 in Tokyo and Osaka. The main features of Digital Radio are

1. High quality audio (CD Quality)

2. Variety of broadcasting services such as Data and Download services

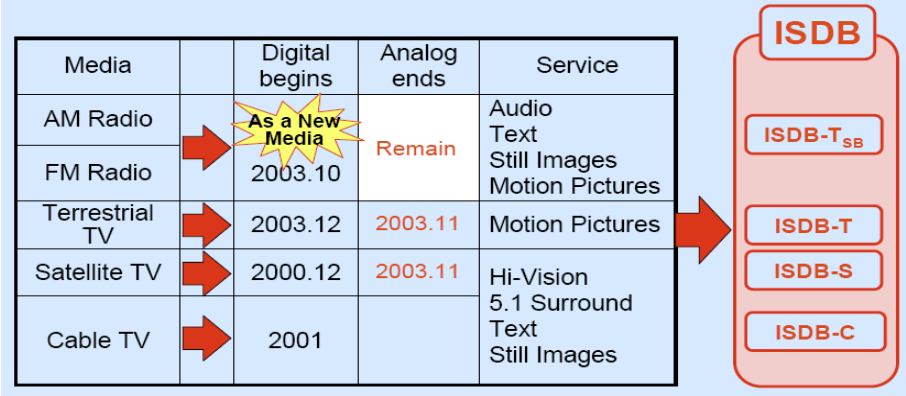
3. More attractive services

4. High quality handheld reception

5. Bi-directional service

Radio broadcaster can send still images and motion pictures and receiver present Electronic Program Guide.

Figure 7; Analog to Digital" by ISDB



VHF

207,5-222MHz – multimedia mobile broadcasting

14,5MHz of spectrum in the VHF high band is assigned for **nationwide broadcasting services**.

[30] might be assigned in this frequency band - ISDB-T for Radio Broadcasting, Part 1: Digitalization of Radio Broadcasting in Japan, 18th March, 2009, KBP ISDB-T Seminar, Manila, Philippines, Hideo FUSEDA, Ministry of Internal Affairs and Communications, JAPAN

[31] ISDB-Tsb technical specification is very similar to the ISDB-T specification, with the exception that ISDB-Tsb uses a form of narrowband transmission with one and three segments.

In December 2009, **ISDB-Tmm has been adopted as one of the standards for nationwide mobile multimedia broadcasting in Japan** and is scheduled to start after July 24, 2011. ISDB-Tmm[32] technology is highly compatible with ISDB-T, which is the standard for the Japanese terrestrial digital broadcasting.

In addition to the ISDB-Tmm standard, Japan's Ministry of Internal Affairs and Communications (MIC) has also recognized **MediaFLO(TM)[33] technology as a second official technology for nationwide mobile multimedia broadcasting services in Japan.**

Broadcasters will choose one of the standards when they apply for a license.

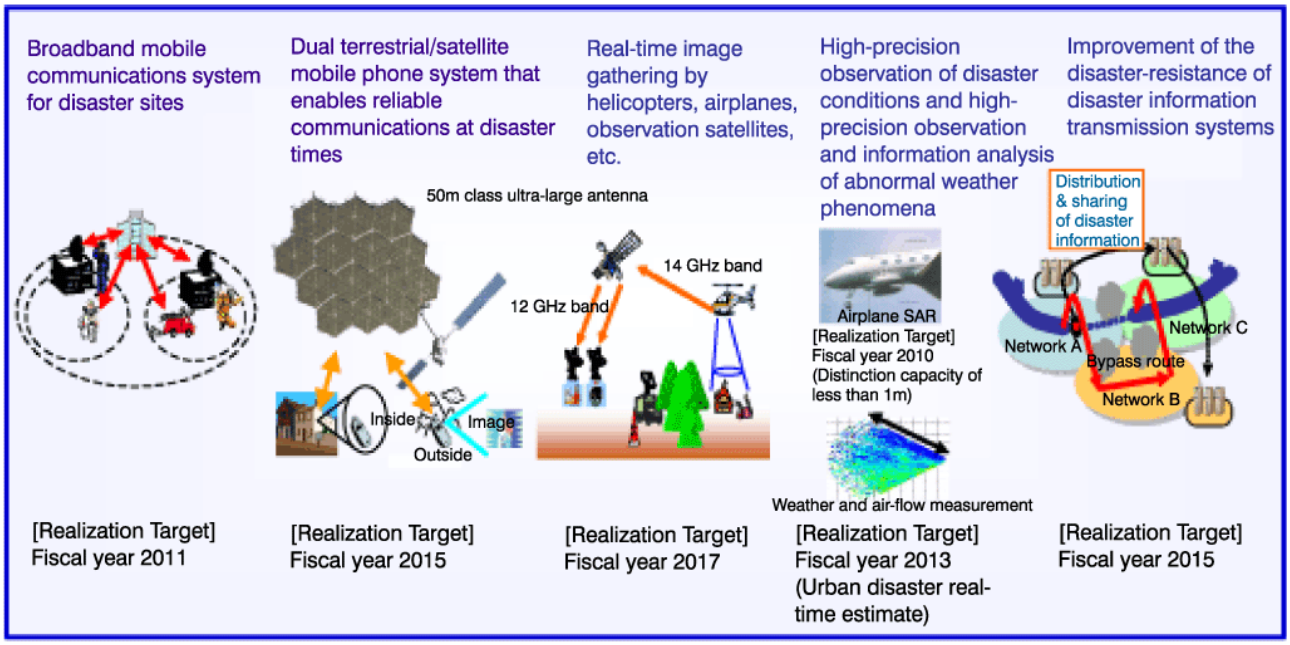
MediaFLO and ISDB-Tmm technologies are view as complementary standards.

VHF

170-202,5 MHz – Private Telecommunications (protection against disasters, etc.)

Secure frequencies for broadband mobile communication systems used for safety and security applications - system mainly for public bodies (local governments, police, and fire departments) which enable to transmit detailed information to enhance public safety and security.

Figure 8; The 5 core technologies that should be strategically promoted



Source: An ICT for Realizing a Safe and Secure Society, Ministry of Internal Affairs and Communication (MIC), Japan, June 2007

[32] ISDB-Tmm (Terrestrial mobile multi-media) will serve for dedicating contents such as sport, movie, music channel and other with CD quality sound.

[33] MediaFLO technology has been trialed using VHF spectrum in 2008. The trial illustrated how MediaFLO technology can be utilized for broadcast delivery of advertising, news and information services to the public at large. The trial employed a variety of MediaFLO services that include linear mobile TV and, for the first time, broadcast delivery of clipcasting media.

http://warp.ndl.go.jp/info:ndljp/pid/258151/www.soumu.go.jp/joho_tsusin/eng/Releases/NewsLetter/Vol18/Vol18_05/Vol18_05.html

The UHF band except those used for digital TV will be used for mobile communications after 2012

UHF

470-710MHz Digital TV Broadcasting (240MHz)

The band may be used for land mobile service on and after 25 July 2012

UHF

715-725MHz Intelligent Transport System (ITS) – 10 MHz

ITS realize vehicle-to-vehicle communication, providing safety assistance to prevent accidents.

The 700 MHz band is suitable for supplying information on hazards that are not visible to the driver, and function that is expected to vehicle to vehicle communication.

Nine Areas of ITS:

1. Advances in Navigation Systems
2. Electronic Toll Collection
3. Assistance for Safe Driving
4. Optimization of Traffic Management
5. Increasing Efficiency in Road Management
6. Support for Public Transport
7. Increasing Efficiency in Commercial
8. Support for Pedestrians
9. Support for Emergency Vehicle Operations

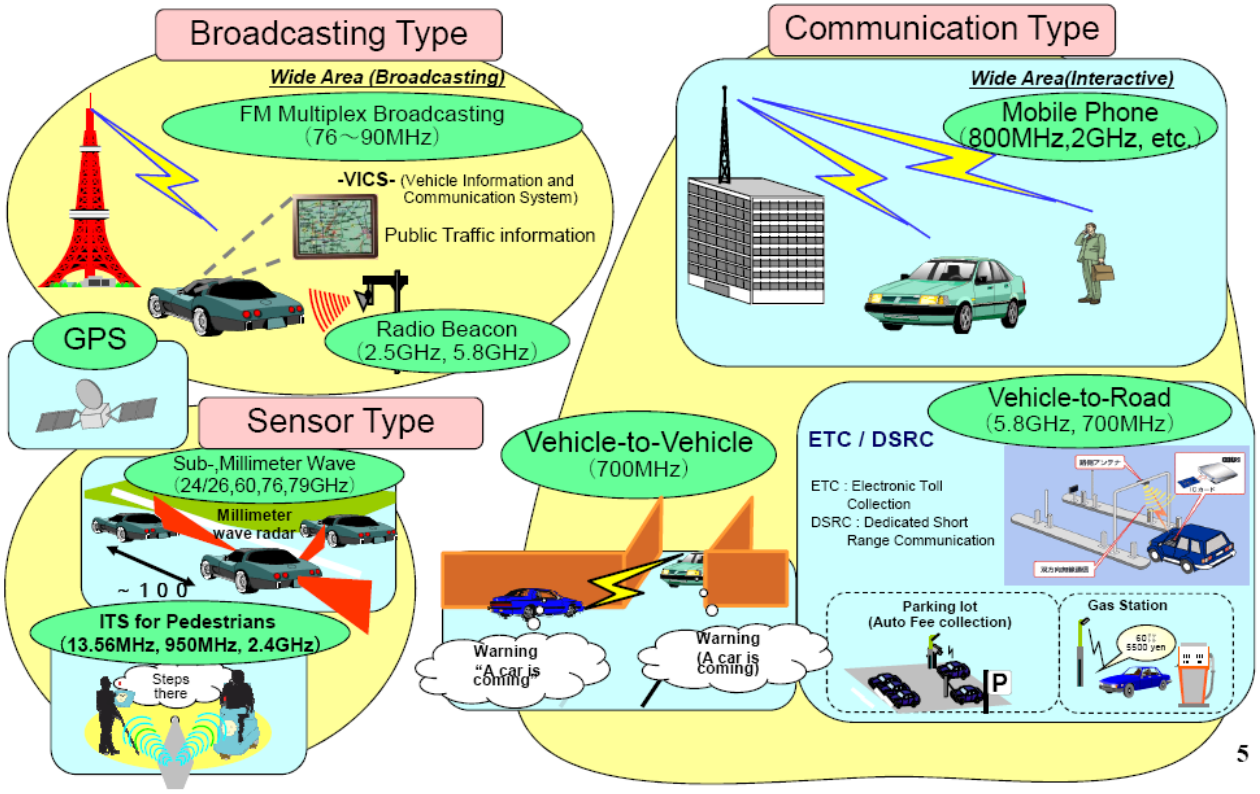
MIC has prepared preferential scheme for flexible spectrum use

Figure 9; ITS Radio Systems in Japan

System	Service	Spectrum	Technical Regulation
VICS: Vehicle Information and Communications System	· Provide traffic information (Broadcast type)	76-90MHz (FM multiplex broadcasting)	Enacted in 1994
		2.5GHz [5.8GHz] (Radio beacon)	
ETC: Electronic Toll Collection	· Collect highway fee (Communication type)	5.8GHz	Enacted in 1997
DSRC: Dedicated Short Range Communication	· Collect highway fee · Provide various applications (Communication & Broadcast type)		Enacted in 2001 (Revised 2007)
Millimeter Wave Radars	· Detect obstacles (Sensor type)	24/26GHz	Will enact in 2010
		60/76GHz	Enacted in 1997
		79GHz	Consideration has been started since Nov. 2009
Safety Driving Support System	· Send safety information (Communication type)	700MHz	Consideration has been started since Jul. 2009

Source: Yasushi Sakanaka, Director for Land Mobile Communications Radio Department, Telecommunications Bureau Ministry of Internal Affairs and Communications, Japan, 2nd ETSI TC ITS Workshop, 10-12 February 2010 - ETSI, Sophia Antipolis, France, February 2010.

Figure 10. Radio Wave Media for ITS



Source: Yasushi Sakanaka, Director for Land Mobile Communications Radio Department, Telecommunications Bureau Ministry of Internal Affairs and Communications, Japan, 2nd ETSI TC ITS Workshop, 10-12 February 2010 - ETSI, Sophia Antipolis, France, February 2010.

UHF

730 – 770 MHz Telecommunications – commercial services (40MHz)

Secure frequencies to address frequency demand caused by growing numbers of mobile phones and other portable devices (demand from current mobile-phone carriers, cellular phones, etc.)

3. UK

1.1 Market overview

The UK's analogue television signals will be switched off, region by region, between 2008 and 2012.

The decision to release a digital dividend was taken by the Government already in 2003. The first plan implied releasing two distinct bands of spectrum, one of which comprised 48 MHz between 806-854 MHz.

In 2009, Ofcom has announced proposals to align more of the spectrum released as part of the UK's digital dividend with other European countries (790-862 MHz).[34]

Government decided that **256MHz (32 channels)** of the 368MHz (49 channels) should be used for **digital terrestrial television (DTT)** from digital switchover. This digital broadcasting will be provided by six multiplexes. The remaining spectrum of **112MHz will be released for new uses.** This 112MHz comprises 14 channels of 8MHz, which is presently used for analogue television, and on a secondary basis for uses such as wireless microphones. Both primary and secondary uses will cease at switchover.

Originally Ofcom promised to safeguard spectrum in the 800MHz band for wireless microphones and digital terrestrial TV services. Now it proposes to make the whole 800MHz band available for mobile broadband and related services and to find 'alternative spectrum' for wireless microphones and digital terrestrial TV."

1.2 Digital dividend

Digital dividend spectrum available for release in UK consists of the three sorts of spectrum:

- **the 112 MHz** mentioned above (these channels are numbered 31-35, 37, 39-40 and 63-68)
- **channel 36 and channel 69** (two blocks of spectrum that fall within the spectrum bands currently used by terrestrial television across Europe). Channel 69 is currently use for wireless microphones and will become unavailable for PMSE use during 2012. Channel 36 was used for airport radar until 2009 and presently is cleared.
- **interleaved spectrum** the "white space" that exists geographically between television transmitters to prevent interference. Ofcom estimates that around 208 MHz of interleaved spectrum may become available. At present, interleaved spectrum in the analogue television bands is used by services known as Programme-Making and Special Events (PMSE). PMSE services include outside broadcasts and televised sporting events such as football matches as well as radio microphones used in theatres and other public venues. Ofcom will consider these existing services carefully in planning for the use of this spectrum after digital switch-over

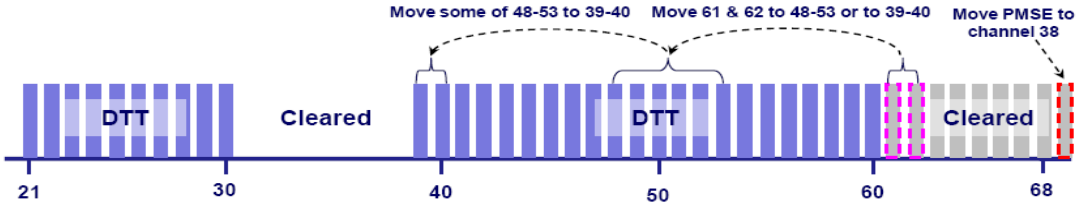
In 2009 Ofcom made proposals to clear channels 61 and 62 to align the 790 – 862 MHz band with other countries in Europe whilst maintaining the existing DTT coverage obligations UK analogue switchover[35].

---

[34] At the World Radio Conference (WRC) held in Geneva in 2007 mobile services were granted co-primary status with broadcast services in UHF channels 61 to 69, the 800MHz Band. The European Commission has also been considering the matter.

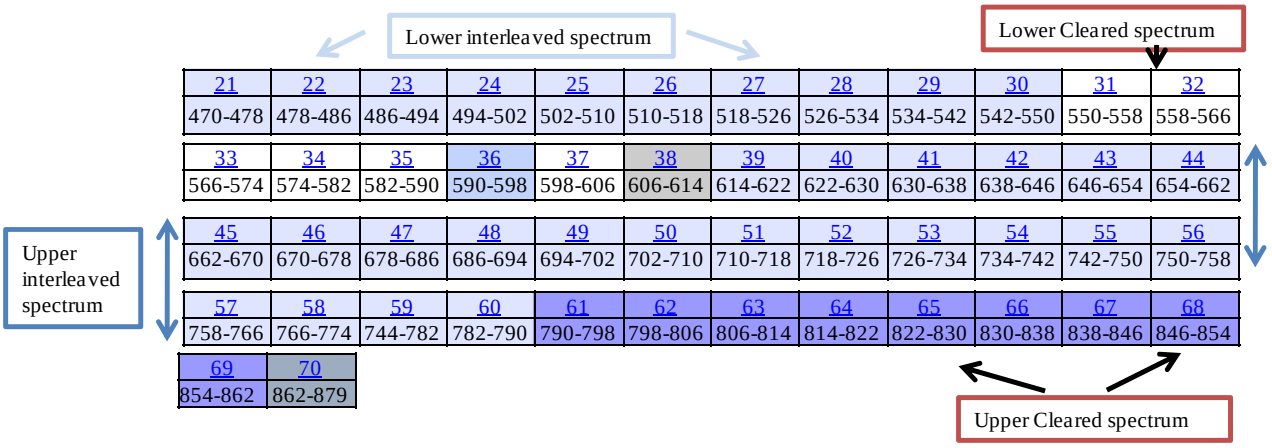
[35] European Commission Hearings on the Digital DividendBrussels, 6 March 2009, UK Broadcasters' perspective on the Digital Dividend, Nigel Laflin, (nigel.laflin@bbc.co.uk) BBC Distribution,

Figure 11, UK proposal to clear the 800 MHz band



The table below illustrates Ofcom's latest proposals/decisions and what this means for PMSE use in the future[36].

Figure 12. Digital dividend in the UK



21	22	23	24	25	26	27	28	29	30	31	32
470-478	478-486	486-494	494-502	502-510	510-518	518-526	526-534	534-542	542-550	550-558	558-566
33	34	35	36	37	38	39	40	41	42	43	44
566-574	574-582	582-590	590-598	598-606	606-614	614-622	622-630	630-638	638-646	646-654	654-662
45	46	47	48	49	50	51	52	53	54	55	56
662-670	670-678	678-686	686-694	694-702	702-710	710-718	718-726	726-734	734-742	742-750	750-758
57	58	59	60	61	62	63	64	65	66	67	68
758-766	766-774	744-782	782-790	790-798	798-806	806-814	814-822	822-830	830-838	838-846	846-854
69	70										
854-862	862-879										

Ch 31 - 37 will be auctioned but will be available for PMSE use until the end of DSO in 2012. This is commonly known as 'cleared' spectrum

Ch 61 - 69 will be auctioned but will be available for PMSE use until at least 1 January 2012, and possibly until the end of DSO in 2012. This is commonly known as 'cleared' spectrum. The 790-862 MHz band will be auctioned to the International Mobile Telecommunications industry (IMT) for the provision of wireless broadband internet services.

Ch 21 - 30 and Ch 39 - 60 will become 'interleaved' spectrum - assigned to Digital TV with some channels auctioned in the DDR geographic interleaved awards (suitable for local TV use). Ch 21 - 30 and Ch 39 - 60 will be available for wireless microphones on a secondary use with Digital Terrestrial Television (DTT) and on a license basis. PMSE use of channels will be protected until 2018.

Ch 38 will be cleared of radio astronomy and will replace Ch 69 available nationwide from January 1, 2012 on a light license basis. Terms of access for Channel 38 will differ from Channel 69 in that the licence will not be limited to specific frequencies; instead a frequency range will be available. (Available for PMSE)

[36] Digital Switchover and the Digital Dividend Review, 04/01/2010,

Ch 36 will be cleared of PMSE and airport radar use and will be made available for award

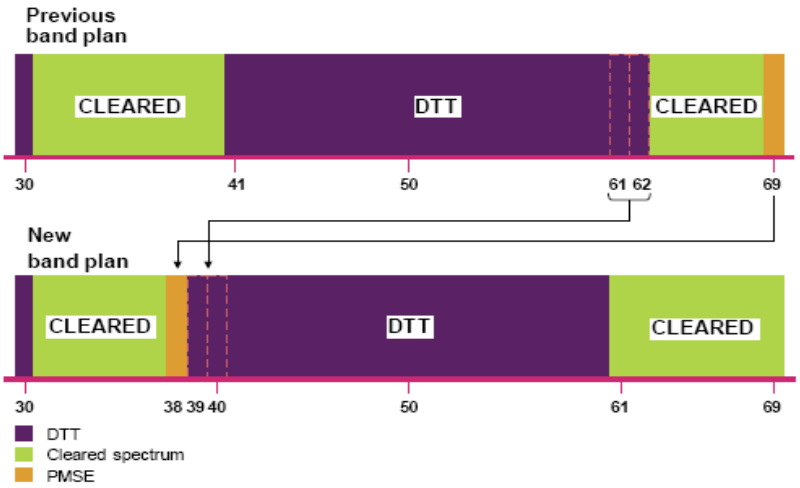
Ch 70 remains unchanged

1.3 Future plans

Figure below illustrates the changes that will need to be made to the configuration of the UK's digital dividend. In effect, DTT in channels 61 and 62 will be moved into channels 39 and 40, and PMSE in channel 69 will be moved into channel 38. This means the cleared spectrum in the digital dividend will comprise 550-606 MHz (channels 31-37, the 600 MHz band) and 790-862 MHz (channels 61-69, the 800 MHz band) [37]

These decisions have the effect of reducing the amount of spectrum available for new services in the lower, 600 MHz band of cleared spectrum.

Figure 13. Changing the configuration of the UK's digital dividend



Source: Digital dividend, Clearing the 800MHz band, Ofcom, June 2009

Potential uses of the 800 MHz band

The **790-862 MHz** band will be auctioned to the International Mobile Telecommunications industry (IMT) for the provision of **wireless broadband Internet services.** The suitability of this spectrum for mobile broadband has led an increasing number of European countries to identify the 800 MHz band as their digital dividend.

Ofcom expects to agree revised interference arrangements for two-way mobile use of the 800 MHz band with Belgium, France, Ireland and the Netherlands through MOUs by mid 2010. This will allow for the deployment of services other than broadcasting. These MOUs will be effective when both administrations make the band available for new services.

Similar services could be accommodated in other spectrum, including the 600 MHz band and geographic interleaved spectrum[38]. However, Ofcom pointed out that there is no any immediate

[37] Clearing the 800MHz band, Ofcom

[38] The operation of mobile-broadband services in geographic interleaved spectrum is uncertain. But if it is feasible – particularly for downlinks (i.e. from base stations to mobile receivers) – geographic

prospect of this beyond the UK, and this may affect the commercial case for mobile-broadband use of these bands.

Potential uses of the 600 MHz band

There is a wide range of potential uses of this spectrum, the most likely of which appear to be DTT and mobile broadband alongside others including mobile multimedia services (MMS e.g. mobile television), programme making and special events (PMSE), broadband wireless access (BWA) and communications for the emergency services.[39]

In the consultation document "Digital dividend: consultation on potential uses of the 600 MHz band and geographic interleaved spectrum" published in February 2010, Ofcom set out an assessments of the likely uses of the cleared and geographic interleaved spectrum. These were:

- **new DTT channels in either SD or HD aimed at a UK market;**
- **new DTT channels aimed at national, regional or local markets;**
- **mobile television;**
- **mobile broadband (including two-way mobile services);**
- **PMSE;**
- **Communications for the emergency services.**

It appears the most likely uses of the **600 MHz** band are **DTT and mobile broadband**. Most responses to the geographic interleaved consultation agreed DTT was the most likely use.[40]

Table below summarises the views provided by stakeholders on the quantity of spectrum they would require for the most likely uses of the cleared and geographic interleaved spectrum.

Table 1. Summary of stakeholder views on spectrum requirements

Use	Likely spectrum requirement per operator
DTT: UK-wide (SD and HD)	8 to 48 MHz cleared
DTT: national/regional/local	8 to 16 MHz interleaved in each area
Mobile television	8 to 24 MHz cleared

interleaved lots could provide new or extended access on a sub-UK basis (e.g. in areas not served by fixed lines or existing wireless networks using higher frequencies). Ofcom has done some work on how mobile communications networks might use the 600 MHz band. This has looked at systems using FDD and time-division duplexing (TDD) and a mixture of the two. Examples of some possibilities are presented in the consultation document "Digital dividend: 600 MHz band and geographic interleaved spectrum, Consultation on potential uses" Ofcom, February 2010

[39] Digital dividend: 600 MHz band and geographic interleaved spectrum, Consultation on potential uses, Ofcom, February 2010

[40] Digital dividend: 600 MHz band and geographic interleaved spectrum, Consultation on potential uses, Ofcom, February 2010

Mobile broadband	10 to 48 MHz cleared
PMSE	8 MHz cleared/interleaved

Sources: Digital dividend: 600 MHz band and geographic interleaved spectrum, Consultation on potential uses, Ofcom, February 2010

The geographic dimension of the spectrum to be offered differs between the 600 MHz band and the geographical interleaved spectrum. Channels in the 600 MHz band will be available for use throughout the UK, although there are likely to be constraints on certain uses in some areas due to international agreements. It would clearly be possible to offer the spectrum as UK-wide lots. It would also be possible to offer it in smaller, geographically defined lots, on a regional, national or some other basis. We will take into account stakeholders' interests in the services and coverage they would like to provide in making proposals for how we should geographically package the band.

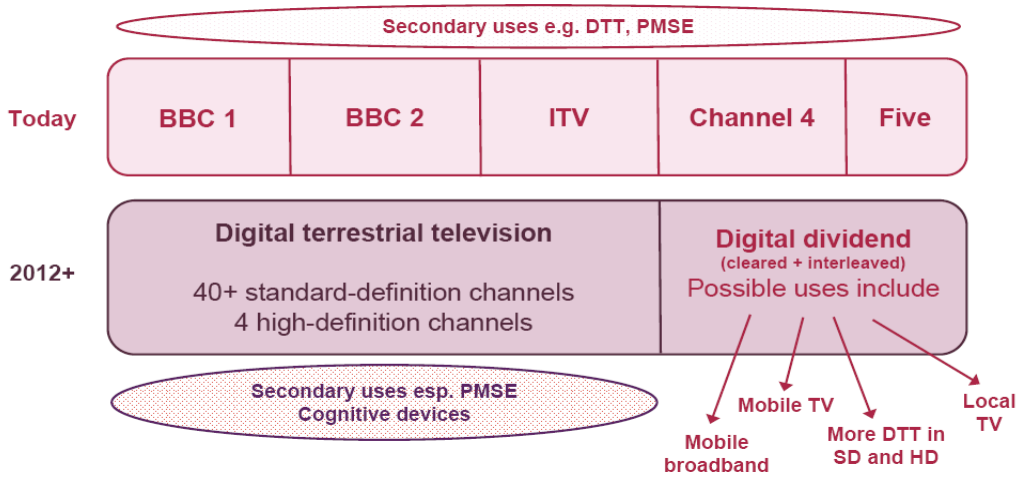
The geographic interleaved spectrum is different from the 600 MHz band in terms of coverage. The spectrum may be used in areas where it is not needed for the six existing DTT multiplexes.

Ofcom will publish detailed proposal for the award of both the 600 MHz band and the geographic interleaved spectrum after mid-2010.

A market-led approach to awarding the digital dividend

Ofcom decided to auction geographic packages of interleaved spectrum in specific locations that matched the pattern of demand for local television. Those packages would be suitable but not reserved for use by local television.

Figure 14. Awarding the UK's digital dividend,



Source: Matthew Conway, Director of Operations, Spectrum Policy Group, February 24, 2009, Awarding the UK's digital dividend,

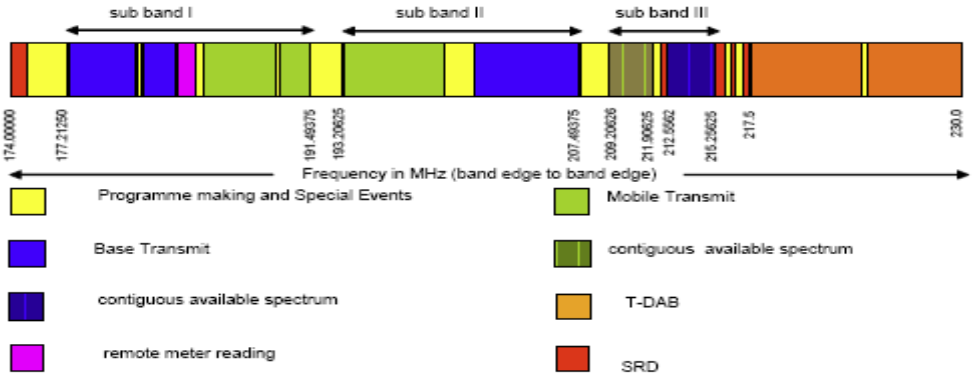
http://www.eett.gr/opencms/export/sites/default/EETT/Events/Events/Imerida240209/Presentations/CONWAY.pdf,

VHF Band III

In the UK, the current primary use of sub-band 3 is for Terrestrial Digital Audio Broadcasting (T-DAB). The UK government in 1994 allocated spectrum for **T-DAB in the range 217.5 to 230.0 MHz**. The band

is also used for **Programme-Making and Special Events (PMSE) and short-range devices (SRDs)** on a secondary basis. The current use of Band III in the UK is as follows:

Figure 15. VHF Band III



Source:

Sub-band 3 (209–215MHz)

This Sub-band has notionally been allocated to 'new technology systems' but no assignments have been made to date. Ofcom estimates that in total 2 × 2.7MHz of contiguous spectrum is available (216 paired 12.5kHz PMR channels). The remaining spectrum in this Sub-band is allocated either solely to programme-making and special events (PMSE) or to both PMSE and short-range devices (SRDs)[41].

The frequencies above Band III (217-230MHz) are allocated to national and local T-DAB multiplexes, which are spaced in accordance with CEPT agreements. All available T-DAB channels are in use; however, in the case of local multiplexes, much of the spectrum is unused on a regional basis, in order to prevent interference between local radio stations. In addition, some designated regional multiplexes have not yet received an application. A small amount of the T-DAB spectrum is shared with PMSE, on a no-interference basis.

The spectrum between the Sub-bands is allocated to PMSE (also SRDs in some cases, although Ofcom said that there are no SRD users).

The scope for interference between the UK and neighbouring countries means that not all of Band III can be used in all parts of the country without constraints due to the need to overcome imported interference effects. Ofcom's Band III assignments are therefore co-ordinated with use of the spectrum in France, Ireland, Belgium and the Netherlands in order to ensure harmful interference does not arise.

Ofcom plan to award all of the spectrum on a UK-wide basis, except for packages in the **interleaved spectrum** that would be suitable **for a variety of local or regional services (e.g. local television)**.

Ofcom proposes to hold three distinct awards of interleaved spectrum:

- a beauty contest for a package with PMSE obligations;

[41] There are no SRDs currently utilising this spectrum

- an auction for geographic packages suitable but not reserved for local television in about 25 locations throughout the UK; and
- an auction for channels 61 and 62 where they are not being used for DTT.

4. Sweden

1.1 Market overview

Sweden completed digital switchover in October 2007. The 790-862 MHZ frequency band had previously been used for terrestrial television broadcasting, but has been released from TV broadcasting and will be use for wireless services. In December 2007, the Government decided that:

- 790-862 MHz (the 800 MHz band) should be vacate
- a six nation multiplexer for digital TV should be established under 790 MHz
- a new multiplex should be established in band III (VHF)

1.2 Digital dividend

Allocation of the digital dividend has been completed in Sweden. A minimum of 6 multiplexes in the UHF frequency bands and 1 multiplex in the VHF band will be available for broadcast services while the UHF Band V spectrum located above 790 MHz is planned to be auctioned and allocated for other services[42].

The following frequency bands for terrestrial television broadcasting were used prior to the switch-off of analogue terrestrial television broadcasting in Sweden:

Table 2. Frequency bands for terrestrial television broadcasting prior to the switch-off of analogue terrestrial television broadcasting

Frequency bands for terrestrial television broadcasting prior to the switch-off of analogue terrestrial television broadcasting			
Frequency range	*Designation*	*Amount of frequencies*	*Channel number*
47–68 MHz	Band I	21 MHz	2–4
174–230 MHz	Band III (VHF)	56 MHz	5–12
470–862 MHz	Band IV/V (UHF)	392 MHz	21–69
'Channel number' refers to the generally accepted numbering of the 7 MHz and 8 MHz channels respectively in Bands I, III, IV and V.			

Sources: The 800 MHz band, Planning and assignment proposals, PTS, 09.2009

[42] Allocation of the digital dividend in Sweden, DigiTAG 2009

1.3 Future plans

In Sweden, the band **790-862 MHz** is already allocated to the **mobile service**, except aeronautical mobile, on a primary basis through footnote RR 5.316[43].

Band I (47 – 68 MHz)

This band will not be used for television or other broadcasting following the switch-off of analogue television broadcasting. Regulator consider that commercial stakeholders will have a limited interest in using this frequency band[44]. There is an interest in this band from:

- The Swedish Armed Forces - using for **military applications**
- and **amateur radio** users

Band III (174 – 230 MHz)

This band will not be used for television broadcasting following the switch-off of analogue television broadcasting.

Band III is already in use in some European countries and will become more fully available by 2015 in accordance with the GE06 Agreement. The GE06 plan is based on 7 MHz raster and is planned in Europe for at least indoor portable reception. The plan opens up opportunities for a structured introduction of T-DAB services in all of Europe and other ITU Region 1 countries[45].

In Sweden the **VHF** band will be used by **T-DAB and by DVB-T** (a nationwide coverage).

According to the outcome of the International Telecommunication Union's Regional Radio Communication Conference (RRC-06) in Geneva in 2006, there is internationally coordinated spectrum within band III (174 – 230 MHz) for one nationwide and three regional T-DAB networks, and one nationwide DVB-T network. **The Government has decided not to further extend digital sound broadcasting in Sweden. Band III, i.e. 56 MHz, would therefore be entirely available for new systems.**

The Swedish Armed Forces have expressed to PTS their interest in the use of the frequency band 230 – 240 MHz, which forms part of Band III, but which may be affected by possible future decisions on the development of digital sound broadcasting (T-DAB).

Bands IV and V (470 – 862 MHz)

Bands IV and V constitute the largest frequency band used for analogue television. Following the switch-off of analogue television broadcasting, the existing five operational DVB-T networks will use this frequency band.[46]

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[43] WRC-07 allocated the band 790-862 MHz to the mobile, except aeronautical mobile, service on a primary basis in Region 1 and identified this band for IMT in Regions 1 and 3. The primary allocation of the whole band 790 - 862 MHz in the entire Region 1, for mobile except aeronautical mobile service will come into effect from 17 June 2015.

[44] This is due to the bandwidth (capacity for data transmission) being limited, and long antennae being used for reception, which impedes the development of portable user terminals.

[45] http://rspg.groups.eu.int/_documents/consultations/comments_multimedia/rep_se_radio.pdf

[46] http://www.pts.se/upload/Documents/EN/Use_of_radio_spectrum_2006_35.pdf

Band **470-790 MHz** will be used by **DVB-T (six nationwide coverages)**, while the **790-862 MHz** sub-band will be released **and used by other services besides broadcasting**.

Existing licenses in 790-862 MHz for applications of PMSE (program making and special events) are granted until the end of 2009. The 800 MHz-band is therefore expected to be available for new uses in the time frame 2009-2010.

Conditions for use of spectrum are formulated in a way that is as **technology and service neutral** as possible. This enables licence holders to choose the technology that they wish to deploy and the services that they want to offer. That means that only the technical requirements that are required to ensure coexistence between different users should be imposed (such as, for instance, emission limits within and outside the frequency band and geographical area to which the licence applies) in order to avoid the occurrence of harmful interference.

No specific date has still been established for the allocation of the band, but it is expected to occur during 2009-2010.

There is some need for reconfiguration of Swedish plans and networks for digital terrestrial television in order to make the 800 MHz-band available for new uses. PTS proposes that the band plan for the 800 MHz band shall be designed in accordance with CEPT's preferred option; that is, frequency separation by 1 MHz to Channel 60, FDD use with 2 × 30 MHz, six paired blocks of 2 × 5 MHz each, together with a duplex gap of 11 MHz.

The spectrum in bands III, IV and V can, following the switch-off of analogue television broadcasting, be used for several different kinds of services.

1. More SDTV programmes (television in standard definition) in terrestrial digital television
2. HDTV (television in higher definition) in digital terrestrial television
3. Mobile television
4. FWA – wireless broadband for fixed reception
5. Mobile broadband/mobile telephony.

In addition to the above-mentioned services, other areas of application may be contemplated within bands I, III, IV and V. These may involve digital sound broadcasting, low-power transmitters, which can be used without a licence, and military systems.

It follows from the outcome of RRC-06 that in Sweden a maximum of two new nationwide DVB-T networks in bands IV and V can be built, in addition to the five pre-existing DVB-T networks. Two DVB-T networks allow up to 14 SDTV programmes in MPEG-2 compressed format.

Figure 16, Frequency Table - 2010

Frequency range	Designation	Use	Note
47–68 MHz	**Band I**		
47–68 MHz		Broadcasting	ST 61, WI95revCO07
47–68 MHz		Land Mobile Radio	Military use
50–52 MHz		Amateur radio	Exemptions from the permit requirement (200 W Max)
174–230 MHz	**Band III (VHF)**		

174–223 MHz		Broadcasting Broadcasting (T-DAB) Broadcasting (DVB-T)	Also DVB-T2 Band III, channel 5-11, GE06
223–230 MHz		Broadcasting Broadcasting (T-DAB) Broadcasting (DVB-T)	Also DVB-T2 Band III, channel 12, GE06
470–862 MHz	**Band IV/V (UHF)**		
470–790 MHz		Wireless microphones	ERC/REC 70-03, Annex 10 e)
470–790 MHz		Broadcasting (DVB-T)	Also DVB-T2 Band IV/V, channel 21-60, GE06 The government's decision 19 December 2007; Ku2007/455/ME Others
790–862 MHz		Digital cellular systems BWA	Block Permits The government's decision 19 December 2007; Ku2007/455/ME Others

Sources: Post- och telestyrelsens allmänna råd (PTSFS 2010:2) om den svenska frekvensplanen, PTS, March 2010, http://www.pts.se/upload/Foreskrifter/Radio/ptsfs-2010-2-allmanna-rad-frekvensplanen.pdf

5. Denmark

1.1 Background

Today, after Analogue shut down there are 8 Multiplexes available in Denmark (MUX1 – MUX8). The allocations are depicted in figure 1. MUX1 and MUX2 are allocated for the public service stations DR and TV2. The administration of MUX3- MUX6 has for a 12 year period (until 2020) been given to a commercial company, Boxer. The use of MUX7 and MUX8 is not yet decided, and will be investigated in this report.

Figure 1. Allocation of MUX1-MUX8 in Denmark

	TV2 REG.	MUX1	MUX2	MUX3	MUX4	MUX5	MUX6	MUX7	MUX8 ****
TOLNE-NIBE	NORD	29	57	50	37	35	39	63 *	5
THISTED	MIDT-VEST	31	42	21	43	22	49	62 *	10
VIDEBÆK	MIDT-VEST	40	59	66	48	52	28	34	10
VIBORG	MIDT-VEST	40	59	66	56	52	45	24	10
HADSTEN + AARHUS	ØSTJYLL.	26	44	69 **	56	55	36	24	5
HEDENSTED	SYD	30	44	33	46	55	36	68 *	7
VARDE	SYD	30	54	33	46	53	28	68 *	7
AABENRAA	SYD	37	50	32	22	64	41	67 *	7
TOMMERUP + SVENDBORG	FYN	25	49	27	22	43	41	61 *	7
VORDINGBORG + NAKSKOV	ØST	58	34	42	38	66	48	63 *	6
JYDERUP	ØST	58	51	42	31	60	23	65	6
KOEBENHAVN	LORRY	53	51	54	31	60	23	67 *	6
ROE	BORNHOLM	59	56	51	32	65	39	62 *	9
		DIGI-TV Regional	DIGI-TV	GK Regional	GK	GK	GK*** Mobil-tv	INNO	INNO

MUX1

DR and TV 2/DANMARK have established mutual cooperation and provide their main TV channels in this platform are 1) DR 1, 2) DR 2, 3) TV 2/DENMARK and 4) Non commercial local TV

MUX2

MUX2 is allocated to DR and contains the following programs:

- DR Ramasjang: Children channel
- DR K: Culture channel
- DR HD: DR's HDTV channel
- DR Update: News channel
- Folketing: A channel transmitting live from the parliament

MUX3 – MUX6

BOXERTV which is the commercial operator and the gate keeper for the digital terrestrial TV in Denmark provides a number of TV services in MUX3-5. These services are bundled in different packages and offered to the users in a model similar to other multi channel platforms like satellite and Cable TV. At the moment BOXERTV provides 31 national and international TV channels in MUX3-5. Apart from these commercial channels all the public service channels (MUX1-2) are available in the BOXERTV's different packages

Between the 1st November 2009 and the 31st October 2010 MUX6 will be used for research purposes. On the1st November 2010 Boxer will take over and MUX6 will be used for mobile TV services using DVB-H standard.

MUX7 – MUX8

MUX7 and MUX 8 are not assigned yet, however, there is a decision that MUX7 will be allocated to commercial mobile broadband services. The use of these MUXes is the focus of the following interviews

1.2 Interviews with selected stake holders in Denmark

In a two months period in the beginning of 2010 a number of interviews with relevant experts and stake holders in Denmark was conducted. The aim was to identify the most optimal applications for the digital dividend spectrum seen from interests of market players and knowledge of the experts. The aim was further to identify if part of the spectrum should be allocated for societal relevant applications.

The interviewees where selected carefully to reflect the different interests from mobile industry, broadcast sector, industry association, and some of the other possible users like public safety and emergency.

1.2.1 Motorola Denmark

On the question about the strategy of the mobile sector related to the digital dividend discussion the answer was that the strategy from mobile industry will be to get access to more spectrums from the 'TV spectrum', this being the 800 MHz spectrum and also the spectrum below 790 MHz.

In the interview the ITS (Intelligent Traffic Systems) and Public safety and emergency were mentioned as relevant and societal important services that can use the 800 MHz spectrum. However the most important use was identified to be Public Safety and emergency. The sectors like Public Safety and Emergency can also have their own spectrum and network; however, it was emphasized that this is not so likely any more in the EU setting.

With regards to the technology choice there was no doubt that the technology for the 800 MHz band in Denmark will be LTE. It was, however, emphasized that seen from public safety point of view the Mobile broadband will be considered as add on to mission critical TETRA systems for high bandwidth services. The strength of Tetra is that it has harmonized spectrum in Europe and this will also be the case for the 800 MHz band

The spectrum should be used for mobile broadband and be driven by the commercial operators. The societal relevant services such as Public safety and emergency can be provided by these networks by putting specific QoS, security and availability requirements on some of these networks. Relevant security level can be obtained by IPSEC in the LTE networks.

Another important point raised was that we see a convergence between the requirements from commercial market and the requirements from public safety, enabling both of them to use the same technology with different configurations

With regards to the VHF band (MUX8) the attitude was clear: Mobile industry is not interested in this spectrum. This is both because the technology is 'clumsy' with telescopic antennas but also because many mobile services need to control the service areas in a geographic manner, and here VHF with its large coverage areas is not appropriate

1.2.2 Motorola Tetra Unit

The interview was focused on the PSE use and the results of the interview are given in the following:

There is no doubt that Public Safety and emergency needs more spectrums and that the 800 MHz spectrum is perfectly suited to the requirements of the industry. There has been used many resources for lobbying at European and national levels to get part in this spectrum. But the battle is lost and there is no hope that PSE will get share in this spectrum.

The requirements from PSE has been to get access to 2 X 10 MHz European wide harmonized spectrum in the 800 MHz band, however, now the target is to get 2 X 10 MHz in the area below 1GHz.

The technology to be deployed in this spectrum will with no doubt be LTE, which also will be deployed in the US.

LTE will not replace TETRA and will complement TETRA, which is dimensioned for mission critical voice traffic.

VHF is not of interest for PSE mainly because of the external antennas

1.2.3 Independent consultant

We should have a roadmap for spectrum needs for societal services. 800 MHz spectrum must be used for mobile broadband and operated by commercial actors. Different user groups like PSE can then get access to these networks and come up with their requirements with regards to QoS, Security, privacy etc.

Nobody from Mobile industry has shown interest in VHF band and probably the best application will be for broadcast services.

1.2.4 Molex

The interview with Molex was primarily focused on the VHF spectrum.
VHF is not interesting for mobile industry. The cells in the VHF band become too big for most mobile services and the size of the Antenna makes it irrelevant for mobile uses.
Another drawback of this technology for communicative services is that there are a number of health issues with the external antennas. This aspect was however difficult to qualify further.

1.2.5 Danish confederation of IT industry

Mobile broadband and in particular access to mobile broadband using dongles connected to labtops will increase dramatically and there will be need for more spectrum resources. The 800MHz spectrum will be used for mobile broadband in Denmark and the attitude from the market is that LTE will be the technological platform deployed in this spectrum.

The societal services that will be important in the future are:

- Mobile health technologies, including remote monitoring of patients
- The intelligent/smart home solutions
- Mobile digital signatur
- Public safety and emergency
- Intelligent Traffic Systems
- Education and teaching

The solution is not to allocate spectrum to specific servcies but to allocate servceis to mobile broadband driven by commercial operators. Then the specific user groups must get guarantied access to the resources in these networks and also they must come up with their specific requirements on QoS etc.

Denmark has the world's largest public sector. This must be utilized in developing new services and here the 800 MHz band can be important.

With regards to the VHF band the attitude from mobile industry is that it is not relevant spectrum for mobile services because of the coverage and the external antenna issues. The most probable use could be for broadcast services. Here we could experiment in deploying DVB-T2 and offering some HDTV services.

1.2.6 The digital Gatekeeper (Boxer)

The role of Boxer is to expand the competition on the Danish TV market. One of the important elements of the DTT was the number of TV services and the offered price regimes. Both the 800 MHz and the VHF band should be used for broadcast TV purposes on technology neutral basis.

Today Boxer has 30 TV services and this is enough for now but when HDTV becomes more popular then Boxer will have shortage of resources.

With regards to the use of the VHF band for broadcast purposes some specific issues are important in the discussion:

- 40% to 50% of household do not own VHF antennas
- It would be important to have a pilot in using DVB-T2 technology in this band. The experiences about using DVB-T2 in the VHF band are limited today
- In Sweden, where boxer's mother company operates there is a push for using the VHF spectrum for broadcasting using DVB-T2 technology

Conclusion

The main question of this report was to address the alternative use of digital dividend spectrum and more specifically to investigate which applications and technologies can be foreseen to be used in 800 MHz band and in the VHF band. These two bands are identified as digital dividend in Denmark. The focus has been very much on alternative uses, including societal communication services like Public Safety and Emergency.

With regards to the 800 MHz band there is a European decision to use the spectrum for mobile broadband on a technology neutral basis. The spectrum will be harmonized at European level and because of its good propagation characteristics will be suited for covering also rural areas with mobile broadband. In Denmark also there is a decision to assign the spectrum to mobile broadband.

The conclusion is then that when it comes to the 800 MHz band the other uses, including the societal services will not get specific allocations of the spectrum in EU. Huge lobbying activities has been there to get access to part of the spectrum, e.g., for Public Service and Emergency services, without positive results. The solution for getting access to the spectrum for alternative uses is identified by the experts and relevant stake holders to be putting specific QoS and availability requirements on some of the commercial networks and use the capacity of these networks for other uses, including the societal services.

In other countries, e.g., in the US and Japan we see specific allocations of the spectrum for specific uses.

The broadcasting community has still the attitude that this spectrum should be used for TV broadcasting purposes, however they have also realized that the battle is lost and part of the spectrum will be given to other communication services, including the mobile services.

When it comes to the VHF we could not find any interest neither from the mobile industry and nor from the other communication services like the PSE. The argument was mainly connected to the technical characteristics of the VHF devices and the characteristics of the spectrum: The devices are ‘clumsy’ with external telescopic antennas and the large extend coverage areas of VHF are not suited to the mobile services of today.

The broadcasters are interested in the spectrum as the large extent coverage is a positive parameter for broadcast services, however also here there are some technical challenges, e.g., the fact that more than 50% of the Danish households must upgrade their terrestrial antennas to be able to get access to these services.

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