Report for the European Commission

'Exploiting the digital dividend' – a European approach

Final report

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Analysys Mason Limited
Bush House, North West Wing
Aldwych
London WC2B 4PJ
UK
Tel: +44 20 7395 9000
Fax: +44 20 7395 9001
enquiries@analysysmason.com
www.analysysmason.com

DotEcon Limited
17 Welbeck Street
London W1G 9XJ
UK

Tel: +44 20 7467 2070
Fax +44 20 7467 2080
info@dotecon.com
www.dotecon.com

Hogan & Hartson LLP
rue de l'Industrie 26
B-1040 Brussels
Belgium

Tel: +32 2 505 0911
Fax: +32 2 505 0996
www.hhlaw.com

About the authors

This report was prepared by Analysys Mason Limited, DotEcon Limited and Hogan & Hartson LLP for the Information Society Directorate-General of the European Commission.

We would like to thank the European Commission, the Radio Spectrum Policy Group and stakeholders from the Member States, Norway and Switzerland for their views, which were a formal input into the study. However, we would like to emphasise that this report is the work of Analysys Mason, DotEcon and Hogan & Hartson, and does not necessarily represent the views of the European Commission or any other group.

Unless otherwise indicated, all figures and tables in this report are sourced from Analysys Mason, DotEcon and Hogan & Hartson.

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Overview of our findings

This report was compiled by Analysys Mason Limited, DotEcon Limited and Hogan & Hartson LLP on behalf of the European Commission. It considers the scope for action at a European Union (EU) level to promote the efficient use of 'digital dividend' spectrum in the 470–862MHz band. The digital dividend is the frequencies freed up as a result of the switchover from analogue TV to more spectrally efficient digital terrestrial TV (DTT). The size of the digital dividend is around 320MHz for most Member States, providing great scope for an expansion of existing TV services and the introduction of new services in the 470–862MHz band.

This report identifies seven potential uses of the digital dividend. The two highest value uses are DTT (including high-definition services) and commercial wireless broadband. Other potential uses include services ancillary to broadcasting and programme making (SAB/SAP, which use applications such as wireless microphones and in-ear monitors), broadcast mobile TV, wireless broadband for public protection and disaster relief (PPDR), cognitive technologies and an innovation reserve. Service providers in these categories value the 470–862MHz band because it offers certain advantages over other frequencies. These include a balance between coverage, capacity and ease of equipment design, and the scope for large contiguous blocks of spectrum to be made available across the EU.

Under the GE-06 agreement, the entire 470–862MHz band is planned for DTT use in Europe (including the use of high-power broadcast transmitters), although other uses are permitted providing they do not interfere with DTT in neighbouring countries. However, in the future, it is likely that the most efficient use of the band involves spectrum being shared by several uses. Our review of existing studies on the digital dividend suggests that a mixed deployment (primarily DTT and wireless broadband but also other uses) could generate between EUR150 billion and EUR700 billion of total value across the EU (discounted value over 15 years). This is incremental value created from using digital dividend spectrum, either in addition to or instead of deploying the same services using other frequency bands or alternative delivery platforms.

Some Member States have also already taken action to allow new uses in the 470–862MHz band. This study focuses on the adoption of a common sub-band, 790–862MHz, across the EU, which would typically provide 2×30MHz for wireless broadband or other potential uses. We note that Member States' positions on the 470–862MHz band appear to have converged during the course of the study, in part because of initiatives by European bodies supporting the adoption of the 790–862MHz sub-band. Our modelling suggests that action to ensure that the sub-band is adopted across *all* Member States by 2015 could generate additional value of up to EUR44 billion over 15 years in net present value.

Our modelling also identifies a possible case for making more spectrum available for wireless broadband or other low- and medium-power uses. We explored two options: adopting a second sub-band of 694–790MHz or clearing high-power DTT entirely from the 470–862MHz band. These options are not practical in the short term as they would significantly affect the ongoing implementation of DTT as a main delivery platform. They might however, become achievable, or at least conceivable, in the longer term (e.g. beyond 2015 or 2020, depending on national situations). In theory, adopting a second sub-band could generate up to EUR30 billion in additional value across the EU, and total clearance could generate up to EUR51 billion. However, these benefits are uncertain; they depend on strong growth in demand for wireless broadband, and potentially another as yet unidentified use. Under our low-demand scenario for wireless broadband, further reducing spectrum available for DTT could lead to an EU-wide loss of up to EUR12 billion, compared to just adopting the 790–862MHz sub-band.

Our study demonstrates that there is a strong European dimension to current and future policy on use of the digital dividend. Decisions in one Member State necessarily have an impact on neighbouring countries. High-power transmissions travel over long distances in the 470–862MHz band, necessitating extensive cross-border coordination in order to manage interference. For most potential uses, it is beneficial if the same broad frequencies are used in order to realise economies of scale in equipment. Roaming is a particular issue for wireless broadband. Positive effects on Member State economies are possible through greater growth, innovation and competition, and from strengthening EU markets for equipment and services. Some potential uses, particularly broadband, are central to EU policy priorities, notably i2010.

We conclude that there is scope for action at the EU level, both to help realise the immediate benefits available from adopting a 790–862MHz sub-band, and to ensure that the EU is positioned to implement possible further clearance of the band, in a timely and coordinated fashion, if future trends in demand for potential uses justify such action. We have two main recommendations for high-level action at the EU level.

- All Member States are required to clear and award the 790–862MHz sub-band by 2015 in a format that enables it to be used for wireless broadband or other electronic communications services. We estimate that this will generate between EUR17 billion and EUR44 billion over 15 years in net present value depending on the demand scenario chosen.

- There should be a review, at a specified point in time (to be scheduled in the short to medium term due to the long spectrum planning cycles involved), to consider preparatory actions for further clearance of spectrum in the 470–862MHz band. However, a decision to commit to this may not be taken until a later date, following a thorough consideration of all costs and benefits associated with such an action, including the potential impact on the public value.

In addition, we recommend these high-level actions are reinforced by a number of sector-specific actions. Most notably, we recommend that all DTT receivers sold in the EU should be required as soon as possible to conform to minimum interference rejection and compression performance standards (equivalent to H.264/MPEG-4 AVC). The cost of this approach is an estimated EUR170 million for EU consumers owing to increased receiver costs, but will be more than compensated by the benefits. The benefits comprise reducing the cost of replacing legacy MPEG-2 only receivers during a migration to more efficient standards such as MPEG-4 (estimated to be EUR700 million), and reducing the risk of delay in adopting the 790–862MHz sub-band.

1 Summary of the report

This report summarises the work carried out by a consortium comprising Analysys Mason Limited, DotEcon Limited and Hogan & Hartson LLP ('the consortium') on behalf of the Information Society and Media Directorate General of the European Commission ('the Commission') in relation to the study "'Exploiting the digital dividend' – a European approach".

The principal objective of the study was to ascertain what action needs to be taken at the European Union (EU) level (over and above actions that can be/are likely to be undertaken by individual Member States) to ensure that the benefits of the digital dividend are maximised across the EU.

A key component of our approach was input from Member States and industry stakeholders. Three events were held during the course of the study: a series of Stakeholders' Hearings held in March 2009 and two Member States' workshops held in April and June 2009. The consortium would like to thank all those organisations and individuals who have contributed to the study by participating in these events or by providing other inputs to the study (e.g. written submissions). This input has been invaluable to the study team and has informed our recommendations.

In this executive summary we summarise in turn the four parts of the report:

- Part A, which provides background information about the digital dividend
- Part B, which examines the factors influencing the use of the digital dividend
- Part C, which explores the rationale for EU-level action, examines the options, and offers recommendations
- Part D, which provides an implementation roadmap and our conclusions.

1.1 Summary of Part A: Background

Part A of the report provides background information about the digital dividend spectrum.

1.1.1 What is the digital dividend?

Section 3 introduces the concept of the digital dividend. Historically analogue terrestrial TV signals have been broadcast mainly in 470–862MHz (known as UHF bands IV and V). The location of this frequency band is illustrated in Figure 1.1 below. The 470–862MHz band is currently divided into 49 spectrum channels of 8MHz numbered from 21 at 470–478MHz to 69 at 854–862MHz.

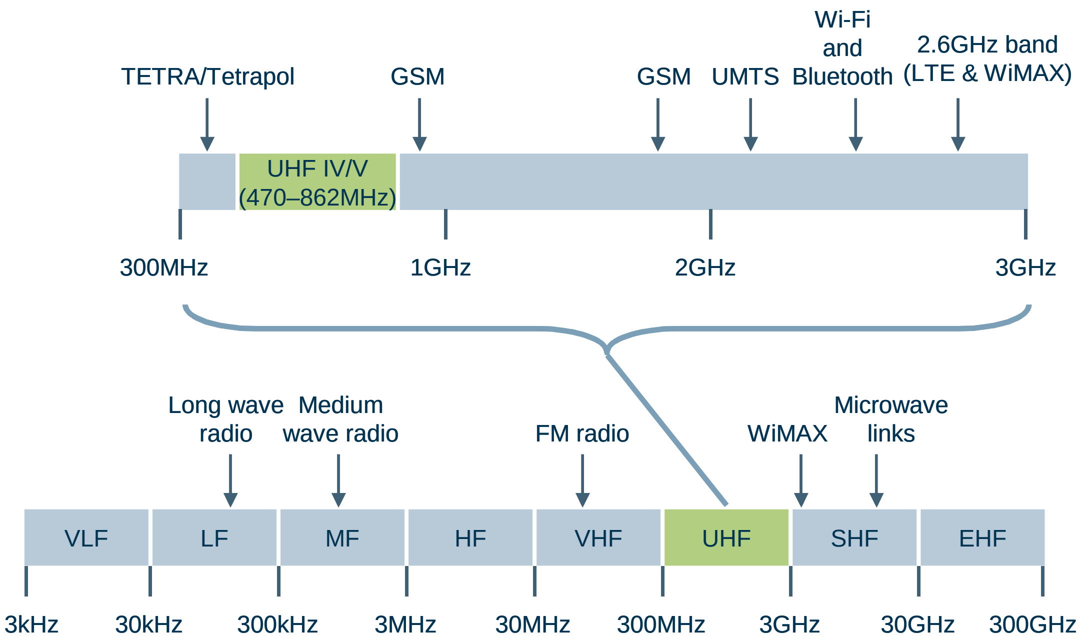

Figure 1.1: *The radio spectrum with current (and future) major uses highlighted [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]*

The switchover from analogue to digital terrestrial TV (DTT) frees up a significant amount of spectrum in the 470–862MHz band owing to the more efficient use of spectrum by digital broadcasting technologies. Member States have either completed, are in the process of, or are planning the transition from analogue to DTT broadcasting, and have generally committed to completing this transition by 2012.

The definition of the term ‘digital dividend’ suggested by the Commission and used in this study is: “… the spectrum over and above the frequencies required to support existing broadcasting services in a fully digital environment, including current public service obligations”. By existing broadcasting services, we mean the analogue TV channels available prior to the launch of DTT. This means that the digital dividend could, in theory, be around 320MHz for most Member States, depending on coordination requirements with neighbouring countries.

The UHF band, and in particular 470–862MHz, is widely regarded as some of the most valuable radio spectrum because it provides a balance between coverage, capacity and ease of equipment design. The amount of spectrum potentially available is large and its use could potentially be harmonised across the EU. Consequently, the digital dividend spectrum is suitable for a wide range of high-value potential uses.

1.1.2 What could the digital dividend be used for?

Section 4 identifies five potential uses of the digital dividend in the EU:

- digital terrestrial TV (DTT)
- broadcast mobile TV
- commercial wireless broadband services, both to fixed locations and to mobile devices
- wireless broadband services for public protection and disaster relief (PPDR)
- services ancillary to broadcasting and programme making (SAB/SAP).

There are many other potential uses of the digital dividend – the above list highlights the main potential uses that are considered further in this report. Although not strictly uses, we have also considered cognitive technologies and an innovation reserve as two further potential 'uses' of the digital dividend. We consider each of these uses in turn below.

Digital terrestrial TV (DTT)

Digital dividend spectrum could be (and in many countries already is being) used to deploy DTT multiplexes to provide standard definition (SDTV) or high definition (HDTV) channels, either free-to-view or on a subscription basis. Services could be national, regional or local. A DTT multiplex is essentially a 'pipe' for the transmission of programming channels. In principle, a multiplex can deliver any picture quality, including HDTV, providing that the services fit the available channel capacity and are receivable at a satisfactory bit error rate.

It is difficult to use other frequency bands outside the 470–862MHz band for DTT services because to do so would require replacement of existing consumer equipment (e.g. aerials and set-top boxes) and the deployment of additional TV transmitters.

Three main factors determine the cost and efficiency (with respect to spectrum use) of DTT deployments: the compression technology, transmission technology and network topology.

There are currently two main compression technologies that can be used for DTT: MPEG-2 and MPEG-4. MPEG-4, and more specifically the H.264/MPEG-4 AVC variant, is approximately twice as efficient as MPEG-2. Of those Member States that have already deployed DTT, 13 have done so using MPEG-2 and six using MPEG-4 for some or all of their transmissions. Amongst other Member States, six seem to be willing to adopt MPEG-4 from the outset. Upgrading a multiplex to deliver MPEG-4 involves minimal cost but there may be a cost to consumers of replacing the receiver (either within the TV set itself or a separate set-top box) with one that is compatible with MPEG-4.

To date, the transmission standard used in Europe has been DVB-T. However, DTT is evolving to use the upcoming DVB-T2 standard, which is likely to enable a 30% increase in capacity. DVB-T2 requires whole multiplexes to be converted from the less advanced DVB-T, which is likely to involve fairly substantial investment for DTT networks. As with MPEG-4, there will also be a cost to consumers, as users’ receivers will need to be replaced with ones that are DVB-T2 compatible.

Figure 1.2 illustrates the approximate number of TV programming channels that can be broadcast on a DTT multiplex using different combinations of MPEG-2/ MPEG-4 and DVB-T/DVB-T2.

	DVB-T		*DVB-T2*	
	SD channels	*HD channels*	*SD channels*	*HD channels*
MPEG-2	8	1	10	2
H.264/MPEG-4 AVC	16	3	20	4

Figure 1.2: TV programming channels per multiplex for DTT [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

DTT networks can be deployed using multi-frequency (MFN) or single frequency networks (SFN) or a combination of the two.

In an MFN, multiplexes use different frequencies at each transmitter site across the Member State. This approach requires a large amount of spectrum, as no two adjacent areas can have broadcasts using the same frequency block; however, it is an effective way of maximising coverage and supporting regional variations in programming.

With an SFN, all the transmitters in a given area (which may be national or regional) use the same spectrum channel and must broadcast exactly the same content (programmes, advertising, data services etc.) everywhere. SFNs may allow more efficient utilisation of spectrum in comparison to traditional MFNs, but may also give rise to interference problems. In particular, in order to deploy national rather than regional SFNs, it may be necessary to use denser networks of transmitters broadcasting at lower power levels. Such networks are more expensive to deploy than MFNs or regional SFNs, especially for rural coverage. In addition, many households would need to upgrade to a wideband antenna or re-align their existing antenna to the new nearest transmitter.

Historically, Member States have used MFNs for analogue TV, which has meant that the whole of the 470–862MHz band has been used for TV. MFNs have also been widely used for DTT networks. Several Member States have deployed high-power, regional SFNs, but only Spain has deployed lower-power national SFNs. Any significant shift to national SFNs would require substantial re-negotiation with neighbouring countries so as to make available the same frequency channel in all areas of the Member State, including border areas. A complete shift to national SFNs may be infeasible for many Member States given domestic commitments to providing regional programming on terrestrial TV.

The frequency requirements for DTT in each Member State will also depend on the availability of substitute delivery platforms and trends in consumer demand. Digital TV is also delivered using cable, satellite and IPTV platforms, but there are coverage limitations to each of these alternatives. Cable and IPTV coverage is typically poorer than DTT in rural areas. Satellite platforms typically have almost total coverage, other than in locations that are shadowed from the signal, or where it is not possible or allowed to erect a satellite dish.

Regarding demand, DTT is part of an advanced trend towards greater TV programming channel choice. Other emerging consumer trends include: growing demand for 'non-linear' services such as video on demand and interactive services; larger TV screen sizes; and growing demand for HD content. Overall, these trends mean that consumers are demanding increased capacity from their TV platforms.

Broadcast mobile TV

Broadcast mobile TV is a service that allows users to receive and watch multiple TV channels using mobile devices (such as a mobile phone). Similar to DTT, this a linear, multicast service (i.e. sent to many devices), which is a much more efficient way of sending TV signals than unicast mobile TV, which is streamed (sent to one device) over a mobile operator's UMTS or HSPA network.

This service requires dedicated mobile broadcast networks, which are currently available in only a few Member States, including Austria, Finland, Italy and the Netherlands. Broadcast mobile TV could potentially be provided using a number of technologies including DVB-T, Digital Video Broadcasting for Handhelds (DVB-H); Digital Multimedia Broadcast (DMB) and MediaFLO. However, the majority of existing and planned broadcast mobile TV networks in Europe use DVB-H. In order to support the simultaneous use of broadcast mobile TV and GSM/3G, mobile TV providers typically prefer frequencies in the low to middle part of the 470–862MHz band (below 750MHz).

Unlike DTT, it would be feasible to provide mobile TV using alternative frequencies, such as 174–230MHz and 1452–1492MHz. However, 470–862MHz is regarded as the most suitable frequency range for mobile TV, as it provides a balance between range of coverage and antenna size. There are also two alternative ways to deliver a mobile TV service.

- Streamed over UMTS, HSPA and, in the future, Long Term Evolution (LTE) networks.
- Using multimedia broadband multicast services (MBMS), which is an enhancement to UMTS/HSPA/LTE networks.

Additionally, a hybrid satellite–terrestrial broadcast mobile TV network could be deployed using DVB-SH technology (a variant of DVB-H). Whilst this standard has also been designed operate in the 470–862MHz band, interest is mainly focused on S-band (2GHz) frequencies following the recent award of assignments in this band by the European Commission.

In order to achieve a greater depth of coverage to handheld devices, mobile TV networks have characteristics more similar to a cellular network than a DTT network. They are mainly operated using medium-power, one-way transmissions.

Until around two years ago there was strong interest from mobile operators and other potential service providers in broadcast mobile TV. Since then, this interest appears to have diminished due to uncertainty over demand. There is increasing demand from consumers for non-linear rather than traditional (linear) broadcasts, which may be better provided in other ways, for example over unicast mobile TV, rather than broadcast mobile TV.

Commercial wireless broadband

The digital dividend could be used to provide wireless broadband services to consumers, either to fixed locations or to mobile terminals. The propagation characteristics of digital dividend spectrum mean that it could be used to increase rural coverage and to improve in-building coverage. However, it is unlikely that wireless broadband systems will be a serious competitor for fixed broadband in urban areas.

In Europe, mobile operators are experiencing a very marked increase in demand for wireless broadband, in response to lower prices, higher speed and more user-friendly mobile devices for accessing the Internet. With expanding Internet use and potential widespread introduction of machine-to-machine (M2M) services, it is possible that demand for mobile broadband may continue to grow rapidly for the foreseeable future.

There are two main technologies that could be used for mobile broadband (which mainly operates using medium-power, two-way transmission):

- **UMTS/LTE.** UMTS is widely deployed across Europe in the 2.1GHz band and is being introduced in other bands (e.g. 900MHz) in some countries. Current and future enhancements (HSPA and HSPA+) offer higher data rates up to 14.4Mbit/s. LTE is a further evolution and is likely to be significantly faster, potentially up to 100Mbit/s. LTE will offer profiles for both time division duplex (TDD), which requires unpaired spectrum, and frequency division duplex (FDD) which requires paired spectrum, but is likely to be deployed initially using FDD. Given the timescale for the release of the digital dividend, it is likely that operators will deploy LTE rather than UMTS.

- **WiMAX.** Originally developed as a fixed–wireless access (FWA) technology, the mobile version of WiMAX is likely to offer speeds similar to HSPA. Although WiMAX offers both TDD and FDD profiles, the most likely deployment will use TDD.

Many mobile operators in Europe and globally have committed to LTE, hence the prospects for WiMAX are unclear, particularly in Europe. If the FDD variant of LTE does indeed emerge as the dominant technology, this may have significant implications for the packaging of any digital dividend spectrum that is released for new uses. Existing FDD technologies require spectrum arranged in fixed duplex pairs, with the implication that all countries must adopt the same band plan if they are to benefits from common economies of scale. This is intrinsically less flexible than TDD technologies that require a single contiguous range of spectrum. We understand that manufacturers are researching the development of FDD technologies that can operate in paired spectrum with variable duplex spacing, which would support greater flexibility in spectrum allocation, but such systems are not expected to be widespread for the foreseeable future.

In theory, all frequencies between 470–862MHz could be used for wireless broadband. However, it is very important that spectrum is harmonised in order to realise economies of scale, particularly for handsets. A 72MHz sub-band from 790MHz upwards has been identified as being potentially suitable for wireless broadband use.

There is already a wide range of alternative frequency bands in use for mobile services, including the 900MHz, 1800MHz, 2.1GHz and 2.6GHz bands. However, amongst these only the 900MHz band offers similar suitability for rural and in-building coverage. As capacity at 900MHz is limited (2×35MHz) and currently used by GSM networks which ideally should be phased out gradually, the 800MHz band could provide valuable additional capacity, especially for providers that do not currently have access to 900MHz spectrum. Moreover, there would be greater scope for operators to acquire larger contiguous blocks of low frequency spectrum (2×10MHz or more) that may support higher speeds, which may be especially valuable in rural areas where it may be uneconomic to roll out services using higher frequency bands.

Wireless broadband for public protection and disaster relief (PPDR)

PPDR users include the primary ‘blue light’ emergency services of police, fire, ambulance, and other security services, such as customs & border control and the lifeboat service. Existing digital trunked PPDR systems are largely based on one of two standards – TETRA and TETRAPOL – using frequencies harmonised for public safety use in the 380–400MHz band. However, these networks only provide voice and narrowband data services. There is an increasing need for PPDR users to access broadband data applications whilst on the move.

There is ongoing debate concerning the future technologies for PPDR, in particular whether they should use overlays to existing systems, such as the TETRA enhanced data service (TEDS), or commercially available wireless broadband technologies (e.g. WiMAX and LTE). The latter could offer economies of scale and superior handset availability but may not be sufficiently reliable as they are optimised for different objectives than PPDR. A further debate is whether, and to what extent it is valuable to, identify a common band for PPDR across the EU, which may facilitate the development of systems that are interoperable across Member States.

Spectrum above 350MHz and below 1GHz is most attractive for any wireless broadband network, and PPDR is no exception. The excellent propagation characteristics of these low frequencies means that fewer base stations are required, enabling a more cost-effective network rollout, while also enabling wide-area, good in-building coverage and non line-of-sight operation that PPDR users require. For example, good in-building coverage is essential for fire fighting.

Recent work has commenced within CEPT to consider future spectrum requirements for PPDR. A number of potential alternative frequency bands are under consideration, including not only the digital dividend spectrum but also spectrum from the 300–400MHz range, 872–876MHz paired with 917–921MHz, the 2GHz band (S-Band) and the 5GHz band.

Wireless broadband networks for PPDR users are mainly operated with medium-power, two-way transmission. Typical power levels for a wide area radio system are similar to those of a cellular network.

Services ancillary to broadcasting and programme making (SAB/SAP)

The SAB/SAP sector comprises professional users such as news-gathering organisations, commercial theatres, broadcasters and major music concerts, as well as community users such as local theatres, schools and churches. They use spectrum for a wide range of applications including wireless microphones, in-ear monitors (IEMs), talkback systems, wireless cameras, and audio and video links.

SAB/SAP already uses the 470–862MHz band in all Member States, primarily for talkback, wireless microphones and IEMs. In general, use is greatest in a modest number of “hotspots” including major metropolitan areas and major sporting locations (e.g. golf courses, Formula 1 circuits). Congestion may occur at certain locations and at certain times of peak demand, but in most other places, and for most of the time, spectrum available to SAB/SAP greatly exceeds demand.

SAB/SAP users in the 470–862MHz band typically require low latency (delay), interference-free operation, and reliable equipment. Most equipment in use in the 470–862MHz band is analogue which is rather inefficient in its use of spectrum (typically, an 8MHz spectrum channel can only support up to only eight users). Users and manufacturers are reluctant to switch to digital equipment, owing to concerns over reliability, cost, performance and equipment size.

When DTT (and, potentially, broadcast mobile TV) networks are deployed using MFN or regional SFN topology, SAB/SAP users can share spectrum with these uses on a geographical or interleaved basis, i.e. using the ‘white spaces’. Therefore, spectrum available for SAB/SAP is scattered across the whole band. If DTT/broadcast mobile TV networks are deployed using a national SFN topology, this will reduce the amount of interleaved spectrum.

In some Member States frequencies in the 470–862MHz band are reserved for SAB/SAP on a national (exclusive) basis. Nationwide channels are particularly popular with touring SAB/SAP users and with non-technical users, as there is no need to re-tune or duplicate equipment for use in different locations. As a result, the majority of SAB/SAP use is located in nationally available spectrum channels. Nevertheless, interleaved spectrum remains important for large events that may require multiple channels and/or low-usage channels that are less vulnerable to interference.

Recent studies have indicated that demand for wireless microphones will grow modestly. From a technical perspective, there are two potential trends: the development and take-up of digital equipment, and the use of alternative technologies such as ultra wideband (UWB), but both are five to ten years away from making a significant impact.

The ability for SAB/SAP to use frequency bands other than 470–862MHz depends on the equipment, but very little current analogue equipment can operate using alternative bands. The CEPT has proposed the 1452–1559MHz and 1785–1800MHz bands as alternatives for digital wireless microphones. However, a study by CSMG[1] concluded that the 470–862MHz band will remain critical to many SAB/SAP users through to at least 2018.

Wireless microphones and audio link services are mainly operated with low-power, one-way or two-way transmissions.

Cognitive technologies

Cognitive technologies are not strictly a service, but a family of technologies which assess whether frequencies are in use in a particular location, and if not, transmit over those frequencies on a licence-exempt basis, without causing harmful interference. As a result, these technologies are particularly suited to using interleaved spectrum and have the potential to support a wide range of uses. This may include high-speed broadband, potentially over both short and long ranges. However, as cognitive technologies are in their infancy, the exact uses they may enable is unclear.

There are three approaches that cognitive technologies can use to determine whether spectrum is available: detection (of other signals); geolocation databases (which are pre-installed) and allow the equipment to look up available frequencies based on its location; and beacon reception (pilot channels that constantly broadcasts data to cognitive devices, enabling them to select an appropriate channel). Although detection is the simplest approach, there are doubts about the reliability of this approach, meaning that the geolocation or beacon approaches may be more feasible in the short-to-medium term. Technical conditions in order to facilitate introduction of cognitive radio technologies are the subject of an ongoing study within CEPT and the ITU, in preparation for WRC-11.

The whole 470–862MHz band, and in particular interleaved spectrum, could be made available for cognitive technologies. Other spectrum bands could also be used, either in addition to or as an alternative to the 470–862MHz band. However, the 470–862MHz band is particularly attractive owing to favourable propagation and antenna characteristics. It is unclear to what extent any

[1] CSMG (November 2008), "Potential for more efficient spectrum use by wireless microphones".

future reduction in interleaved spectrum availability in the 470–862MHz band might limit capacity availability for cognitive systems.

Cognitive technologies stakeholders claim that they could use the 470–862MHz at up to 100mW with limited interference. Where services use interleaved spectrum on a cognitive basis, there may be other parameters required to define the system's performance in addition to power levels, such as its sensitivity level. This is to ensure that devices are able to successfully detect other transmissions within the area and avoid transmitting on that frequency.

Innovation reserve

Like cognitive technologies, this category does not comprise a specific service that could be provided using digital dividend spectrum. Instead it relates to the principle of reserving part of the digital dividend for innovation. Such an approach could be adopted for two reasons:

- reserving spectrum specifically for experimental purposes such as trialling new technologies
- not making spectrum available until a future date.

The main argument against creating such an innovation reserve is the opportunity cost of the digital dividend spectrum. Other frequency bands (with lower opportunity costs) could be used to trial innovative services, unless the special characteristics of the 470–862MHz band were required for proof of concept.

1.1.3 How is the 470–862MHz band currently managed?

Following our review of prospective uses of the digital dividend, Section 5 surveys how the 470–862MHz band is currently managed. Member States are generally responsible for decisions on radio spectrum allocations subject to the scope of the electronic communications regulatory framework. For interference management reasons, Member States also work closely with their neighbours through the ITU and CEPT. In particular, the GE-06 Agreement sets the parameters for how the 470–862MHz band is used. Under the Agreement, individual countries are granted the right to assign specific frequencies for DTT, at particular locations and at particular power levels. In principle, Member States have significant flexibility over how they interpret ITU agreements but for practical (interference mitigation) reasons, they are generally are unwilling to operate completely outside of the bounds of the ITU Radio Regulations and GE-06.

Member States can introduce other services in the 470–862MHz band while staying within the GE-06 plan. However, at any given frequency, other services cannot cause more interference to neighbours than the corresponding DTT transmission would have caused. In addition, they will not receive protection from interference from international DTT transmissions. This places a practical limit on which spectrum channels can be used for other services, particularly in border areas.

WRC-07 raised the status of mobile telecommunications in the 790–862MHz sub-band within Europe to be co-primary with DTT – thus giving it equal protection rights. The next World Radiocommunication Conference in 2011 (recently rescheduled to 2012) will consider ongoing studies on mobile applications (e.g. wireless broadband) and other services that could be provided in that sub-band.

Against this international backdrop, the EU has worked to develop a common approach towards the digital dividend. Both the Council and European Parliament have called upon Member States to cooperate in achieving this harmonisation. The Radio Spectrum Committee issued mandates to CEPT to examine the technical considerations relating to the digital dividend, which has already resulted in three reports. CEPT working groups and project teams are also considering potential band plans for the 790–862MHz sub-band, as illustrated in Figure 1.3.

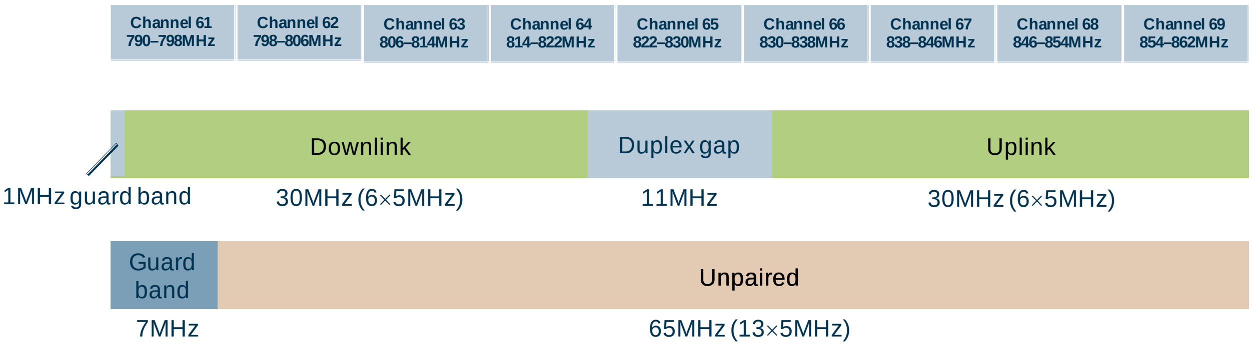

Figure 1.3: Draft harmonised channel arrangements for the 790–862MHz sub-band [Source: ECC PT1]

In November 2007, the Commission released a Communication on developing a common approach. The Commission suggested considering a harmonised set of 'clusters' of sub-bands within the entire 470–862MHz band. Following the Communication, the Council and Parliament have called for a wide and open investigation – of which this study is a part.[2]

1.1.4 National situations within Member States

Section 6 assesses the historic, current and future planned use of the 470–862MHz band by individual Member States. This is largely based on questionnaire responses from all but four Member States, and unless otherwise stated is accurate as at January 2009. With respect to historic and current use, the main observations are as follows:

- The main historic use of the 470–862MHz band in most Member States was analogue terrestrial TV. However, the importance of this platform varied widely. Terrestrial TV was the most-used TV platform in only 10 of the 27 countries. In the other 17 states, more

2 Subsequently, in July 2009, based partially on draft recommendations from this report, the Commission launched a consultation on possible actions to promote coordination of frequency use in the 470–862MHz band.

than 50% of households relied primarily on cable or satellite for their primary TV set, although terrestrial TV was often critical in remote areas not served by cable TV networks.

- In most Member States between four and six national analogue TV programming channels were broadcast. In addition, some Member States also had several regional or local programming channels.

- By the end of 2008, 20 Member States had begun DTT transmissions. Ireland, Poland, Portugal, Romania, Slovakia and Slovenia planned to start digital transmissions in 2009 and Cyprus is expected to follow in 2010. Member States have launched between two and eight DTT multiplexes, covering the majority of their population, with each multiplex carrying between four and seven DTT programming channels. In ten Member States, both free-to-view and subscription-based TV programming channels are available on DTT; in some (typically those with extensive cable TV take-up such as Austria, Denmark and Belgium), DTT is offered solely as a free-to-view service.

- SAB/SAP (including wireless microphones) is deployed in the 470–862MHz band in all Member States, but use is spread widely across the whole band and usually on a secondary basis to use for TV broadcasting. SAB/SAP typically uses interleaved spectrum , but some Member States have allocated specific frequency channels or sub-bands on a nationwide basis to these uses.

- The current GE-06 plans indicate that 14 Member States have allocated or plan to allocate a multiplex for the provision of broadcast mobile TV using DVB-H technology, in addition to their existing DTT platforms.

Figure 1.4 shows the target analogue switch-off dates for those Member States that have a digital switchover plan. Romania and Ireland are still developing their DSO plans with the intention of completing switchover in 2012. Poland is planning DSO in 2015, but could achieve this sooner depending on market conditions. The average simulcast period for analogue and digital terrestrial TV in Member States is about five and a half years. It is not clear how widespread HDTV deployment will be in Member States as only a few Member States are broadcasting in HD or have set out firm plans to broadcast in HD following DSO.

2008 (or earlier)	2009	2010	2011	2012
Finland Germany Luxembourg Netherlands Sweden	Denmark Greece	Austria Estonia Malta Spain	Belgium Cyprus France Hungary Latvia	Bulgaria Czech Republic Italy Lithuania Portugal Romania Slovakia Slovenia UK

Figure 1.4: Expected analogue switch-off dates in Member States[3] [Source: Cocom, 2009]

The majority of Member States are still undecided on the future use of their digital dividend, and are considering various uses such as additional DTT multiplexes (for both SD and HDTV), wireless broadband, SAB/SAP applications and broadcast mobile TV. However, a number of Member States are considering or have decided to free up 72MHz of spectrum to adopt a 790–862MHz sub-band, and either allocate this spectrum for wireless broadband services or make it available for the market to decide the best use. Figure 1.5 outlines the current plans of Member States for the 790–862MHz sub-band.

Current plans for 790–862MHz frequency range post –DSO[4]	*Member States*
Making this sub-band available for wireless broadband or other services	Denmark, Finland, France, Germany, the Netherlands, Spain, Sweden and the UK
Considering making this sub-band available for wireless broadband or other services	The Czech Republic, Ireland, Luxembourg, Hungary and Slovakia
Undecided on the use of the 790–862MHz frequency range	Austria, Belgium, Bulgaria, Cyprus, Estonia, Greece, Italy, Latvia, Lithuania, the Netherlands, Poland, Portugal, Romania and Slovenia
Plans to award all of the digital dividend to DTT	Malta

Figure 1.5: The plans of Member States for the use of the 790–862MHz sub-band (as of December 2008) [Source Analysys Mason, DotEcon and Hogan & Hartson, 2009][5]

3 The switch-off date of 2015 for Poland is still an estimate. Ireland is expected to switch-off by 2012, but has yet to confirm this date.

4 Based on questionnaire responses from January 2009 and any more recent announcements made by SMAs.

5 Information for Belgium, Italy, Greece and Poland is not available.

On the borders of the EU, both Croatia and Switzerland have indicated that they intend to allocate the 790–862MHz sub-band to wireless broadband, whilst Norway will allocate its use by beauty contest, potentially for wireless broadband. A lack of clarity over the plans of Russia and Turkey may impact on Eastern European Member States.

Decisions made in other major economies with regard to uses of the 470–862MHz band and choices of technology and standard could create economies of scale for the EU. In particular, it may be possible for Member States wishing to make a second sub-band below 790MHz available for wireless broadband service, to align with part of the 700MHz band plan in the USA (698–716MHz paired with 728–746MHz, or 746–760MHz paired with 776–790MHz). Another option may be to align to a band plan in Japan which will be in the 710–770MHz range.

1.2 Summary of Part B: Factors influencing the use of the digital dividend

Part B of the report examines the factors influencing the use of the digital dividend, including the spectrum requirements and compatibility of each potential use; national and EU policies related to the digital dividend; and the incremental value to society (both private and external) that each use could generate.

1.2.1 Technical constraints on the use of the 470–862MHz band

Section 7 considers technical constraints on the use of the 470–862MHz band, and discusses the typical spectrum requirements of each use in terms of minimum channel width, total quantity of spectrum required per user and interference issues.

In general, there are two types of interference that might occur:

- interference between systems operating in *neighbouring* frequency bands (*adjacent channel interference*)
- interference between systems operating in the *same* frequency band but in different geographic areas (*co-channel interference*).

With respect to adjacent channel interference, the most difficult issue appears to be DTT interfering with mobile uplinks (i.e. wireless broadband base station receivers), for which a frequency separation of 16MHz is recommended. The proposed FDD band plan being developed by ECC PT1 for the sub-band 790–862MHz suggests that the mobile uplink is accommodated in the upper part of the band (with the downlink in the lower part), which provides the necessary frequency separation. In the case of TDD, as uplinks and downlinks transmit over the same frequency channel in a TDD system, a 7MHz guard band is proposed within the draft harmonised plan being developed by ECC PT1 to prevent interference to DTT. SAB/SAP will normally be able to operate in a channel immediately adjacent to DTT, and broadcast mobile TV can be deployed anywhere in the 470–750MHz band using existing GE-06 allocations. No guard band is required between like services (e.g. adjacent DTT transmissions).

Many existing DTT receivers are susceptible to interference from transmissions that are nine channels above the wanted signal due to the so-called 'n+9' channel issue. There are ongoing studies in various Member States to compare the performance of different DTT receivers regarding this issue, as receiver types differ in their susceptibility to this problem. However, this issue may mean that alternative uses may not introduces into the 470–862Mhz band, without interfering with potentially a significant number of DTT receivers.

With respect to co-channel interference, there are issues that could affect most potential uses. In particular, high-power DTT transmissions in one Member State will pose constraints on use of the same frequencies in neighbouring states; the extent of these constraints depends on the transmitter position and geography. Wireless broadband, especially FDD uplinks and TDD systems, are vulnerable to co-channel interference over large distances from national borders. Mitigation steps are possible by both the victim wireless broadband networks and the interfering DTT networks, but both would result in increased deployment costs. However, as long as interfering DTT networks operate within their permitted emissions levels, as determined by GE-06 or other bilateral agreements, they are under no obligation to take such mitigation steps.

DTT, mobile TV, SAB/SAP and cognitive radio are affected to a lesser extent. As SAB/SAP is likely be able to operate in the channel immediately adjacent to DTT, it will be easier for SAB/SAP to interleave with DTT than analogue TV. However, this beneficial effect may be offset by the fact that most Member States plan to deploy more DTT multiplexes than they did analogue channels. It is unclear whether it will be practically feasible for cognitive technologies to interleave with DTT and/or broadcast mobile TV. Work on this issue continues at both technical (CEPT) and policy (RSPG) levels.

Management of co-channel interference between wireless broadband networks in border areas is already managed by operators and spectrum authorities based upon well-established and understood coordination methods. For this reason, it is easier to manage interference between like systems such as wireless broadband systems of a similar type, operating in similar channel arrangements.

In addition to the above interference issues between spectrum users, we understand that there is the potential for signals in the 470–862MHz band, and in particularly wireless broadband, to interfere with cable networks, particularly with cable wiring at customer premises. This issue has come to our attention late in the course of this study, and therefore, it has not been possible to conduct a thorough evaluation of its impacts. However, we note that the impact will be largely dependent on specific, national situations regarding the roll-out and use of cable networks. Given that interference from wireless broadband transmission in one Member State is unlikely to significantly interfere with cable networks in another Member State, there does not appear to be a significant European dimension to this issue.

1.2.2 Policies related to the digital dividend and its potential uses

Section 8 considers policies that may influence decisions regarding the digital dividend at a European, national or regional level. It provides an overview of relevant Community policies, and also discusses specific policy objectives faced by regulators, such as: promoting growth, innovation and competition in communication services; facilitating universal access to key services; and supporting regional policy.

At the EU level, there are three main policy areas relevant to the digital dividend. Any approach to the digital dividend must firstly be consistent with horizontal policies (internal market, competition, innovation, inclusion, etc.). Secondly, there are relevant policies derived from the i2010 policy framework, the leading policy strategy for the ICT sector, such as "broadband for all" and most recently the European Economic Recovery Plan. Finally, there are the spectrum management policies contained within the Electronic Communications Regulatory Framework, which aim to promote the efficient and effective use of spectrum.

Growth, innovation and competition across the EU are supported by access to spectrum, especially low frequencies with attractive propagation characteristics. Intervention by SMAs to promote the availability of this spectrum for a particular use may encourage this economic development, but a balance is needed between supporting growth and competition in specific industries (such as DTT, and wireless broadband), and maintaining access for innovative uses.

At the national level, attention has typically been focused on the provision of television and broadband services. This is unsurprising given the high economic and public value attached to these services. Television is recognised as a key economic sector, a crucial source of public value and a service that should be universally available. Broadband is perceived as an enabler of economic growth and innovation. However, the focus on television and broadband raises concerns that related policy decisions may be made in isolation from one other, and from decisions on other potential uses of the 470–862MHz band. It is already apparent that in some Member States, the ability of regulators to identify larger blocks of digital dividend spectrum suitable for wireless broadband is complicated by earlier domestic decisions and multilateral accords on the deployment of DTT in the band. In order to optimise spectrum allocation, it is essential to take a holistic approach to management of the 470–862MHz band that considers the opportunity cost of denying alternative uses access to the spectrum. This is likely to involve a combination of market mechanisms and carefully considered policy interventions.

When weighing up the case for intervention to support a particular use, there is a risk that focus could be on the *overall* benefit of the potential uses rather than the *incremental* benefit, both private and external, from using digital dividend spectrum. Certain uses, such as TV and broadband, are very valuable, but a significant proportion of this value may be realised by alternative platforms, such as cable, DSL and satellite, or alternative spectrum bands. Furthermore, much of the value associated with a particular use may be realised through a critical mass of spectrum provision within the band; incremental value from using additional spectrum may be quite modest. Failure to consider the incremental value may lead to a Member State overvaluing a potential use of the digital dividend to the detriment of others.

In regional policies, there are often close links between promoting regional economic, social development and the preservation of regional culture and identity. The most prominent example of intervention in spectrum to support regional policy is in TV. The digital dividend provides an opportunity to expand the provision of regional and local communication services and could support a significant expansion of local and regional TV. However, any intervention to effect this expansion should take into account the opportunity costs of excluding of other uses.

More generally, there is a strong European dimension to decisions about the allocation of the 470–862MHz band. Policy decisions in one Member State necessarily have an impact on neighbours, owing to requirements for frequency coordination and the importance of economies of scale in equipment. For most potential uses, it is beneficial if the same broad frequencies are used across Member States in order to realise economies of scale. Roaming is a particular issue for wireless broadband and (possibly) mobile TV services. There are also positive effects on Member State economies through greater growth, innovation and competition from the strengthening European markets for equipment and services. Some potential uses, most notably broadband, are central to EU policy priorities, notably i2010 and the European Economic Recovery Plan. Thus, if Member States base their decisions on incomplete or inaccurate assessments, or take decisions in isolation from the broader EU context, there is a risk that all Member States will suffer to some extent.

1.2.3 Demand for and value of the digital dividend from potential uses

Section 9 considers the potential value that could be generated from the digital dividend by potential uses, and the possible evolution of demand for these uses.

Total value is defined as the sum of private value and external value:

- **Private value** is the direct benefit to individuals from their own consumption of a service (i.e. the value consumers place on the service), less the costs of producing the service. In economic terms, this is equal to the sum of consumer and producer surplus.
- **External value** is the additional benefit to consumers or third parties not reflected in the value of the service to consumers. This broad definition captures all types of externalities[6], including (1) **public value**, meaning the value that the public derives from services because of their broader contribution to society, such as social cohesion, universal service provision and contributions to culture and education, and (2) **other sources of value**, such as investment spill-overs (consequential benefits for other sectors of the economy) and non-internalised network effects.

[6] Externalities are the unintended effects of economic activity on third parties.

When considering the total value that could be generated by the digital dividend, it is important to take an *incremental* view. For each service, what matters is the incremental value generated by that service from using spectrum in the 470–862MHz band over and above the value that would be realised if the service was only provided by alternative means. If a service can only be provided using digital dividend spectrum, total value would include all benefits (less costs) associated with the service. However, if a service could be provided using alternative means, such as another spectrum band or via fixed networks, we are only concerned with the *incremental value* from using digital dividend spectrum.

A number of previous studies have attempted to estimate the total value associated with potential uses of the digital dividend. Each confirmed that there is sizable private value associated with the digital dividend spectrum, in the order or hundreds of billions of Euros. However, certain potential uses appear to bring more private value than others; in particular there is significant value from using the digital dividend for DTT and wireless broadband. Most of these studies agree that the digital dividend is likely to be shared between several uses. Taken together, the lead studies suggest that a mixed deployment of uses (primarily DTT and wireless broadband but also others) could generate between EUR150 billion and EUR600 billion of private value across the EU (discounted value over 15 years).

None of the studies provide a clear, reliable basis for estimating the public value. The only quantitative benchmark available is from Ofcom, which estimates incremental public value for all uses (except the first six DTT multiplexes) at between 5% and 15% of private value. In Member States where the DTT platform is a major platform, the external value associated with the first six multiplexes may be significantly higher than this. If we extrapolate this estimate across the EU, we can estimate incremental external value at between EUR7.5 billion and EUR90 billion, excluding any additional benefits from having a critical mass of DTT.

Based on the above figures, we estimate the total value that could be generated by the digital dividend (private value plus public value) is estimated to be between approximately EUR150 billion and EUR700 billion across the EU (discounted value over 15 years).

1.2.4 Demand for the digital dividend

Section 10 considers the possible evolution of demand for spectrum 470–862MHz band in the from potential uses. It is apparent that the key determinants will be spectrum demand for DTT and for wireless broadband, as these are likely to be the highest value uses as well as the largest users of the band. There is uncertainty about how demand for these services will evolve (especially wireless broadband), and therefore how the demand for spectrum will develop. Individual Member States are likely to experience different levels of demand for DTT and wireless broadband, depending on factors such as geography, population density and availability of alternative platforms. Nevertheless, we have defined low, medium and high spectrum demand scenarios for both of these uses. Note that we have deliberately considered a wide range of scenarios, including some relatively radical scenarios, in order to understand their impact of spectrum demand.

In Figure 1.6 below we have combined the spectrum demand for both uses, the shaded cells denote combinations for which there is not enough spectrum in the band.

		Spectrum demand for DTT		
		Low (0MHz)	*Medium (320MHz)*	*High (512MHz)*
Spectrum demand for wireless broadband	*Low (0MHz)*	0MHz	320MHz	512MHz
	Medium (80MHz)	80MHz	400MHz	592MHz
	High (240MHz)	240MHz	560MHz	752MHz

Figure 1.6: Potential aggregated demand for digital dividend spectrum from DTT and wireless broadband [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

It is clear from this approach that demand for digital dividend spectrum may exceed supply across some or all Member States.

1.3 Summary of Part C: Rationale and options for EU-level action

Part C of the report explores the rationale for EU-level action, examines the options, and offers recommendations.

1.3.1 The European dimension relating to the digital dividend and a framework for recommendations

Section 11 considers the 'European dimension' of the digital dividend and presents a framework for generating recommendations. EU-level action may be taken in order to meet EU policy goals, or to increase the total benefit to Member States over and above that which would be realised if Member States took uncoordinated action.

The value that is realised from the digital dividend will depend on how this scarce resource is divided among the various uses to which it could be devoted. Optimally, from an EU-level perspective, the 470–862MHz band should be divided among uses in such a way that the total economic value generated over the long term for the EU is maximised. Coordinated action by the Commission regarding the digital dividend spectrum may be warranted based on:

- EU policy goals, such horizontal policies of completion of the internal market, competition, innovation and inclusion; the Electronic Communications Regulatory Framework governing spectrum management; and the i2010 agenda for creating a knowledge-based economy and bridging the broadband gap

- coordination of cross-border interference, whereby high-power use such as DTT in one Member State could prevent the same frequencies being used in another

- economies of scale in equipment manufacture and international roaming/interoperability, aided by a common frequency allocation and common adoption of standards.

The economic value generated by the 470–862MHz band will depend on how spectrum supply and demand are matched, as illustrated in Figure 1.7. Spectrum supply refers to the allocation of spectrum and the conditions of spectrum use in Member States, while spectrum demand refers to the (efficient) demand for spectrum to support various services to consumers.

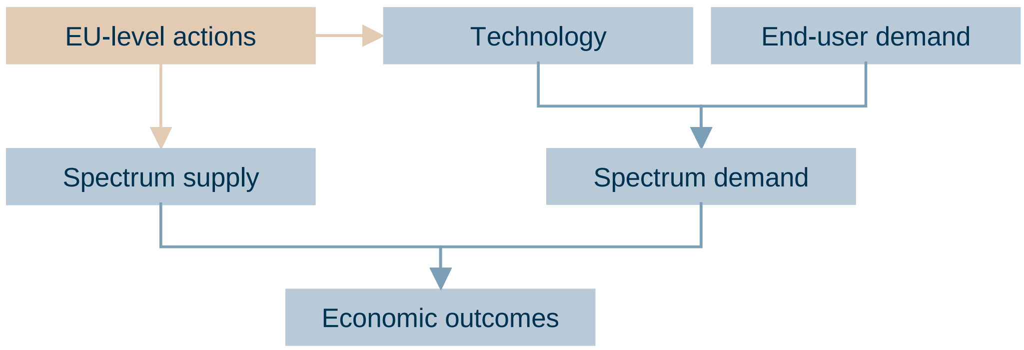

Figure 1.7: How the economic value generated by the 470–862MHz band will be determined [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

EU-level action can primarily influence the decisions of spectrum authorities regarding spectrum supply. However, it can also have some impact on the choice and take-up of particular technologies (including modes of implementation).

Our approach to developing recommended EU-level actions is as follows:

- we develop a broad range of scenario for potential spectrum supply and demand for potential uses of the 470–862MHz band
- we conduct economic analysis to establish the most beneficial broad scenarios
- we then develop and assess options for EU level action.

1.3.2 Broad scenarios for spectrum supply and demand in the 470–862MHz band

Section 12 assesses how the magnitude of economic benefits from the digital dividend across the EU over the next 15 years could vary under different broad scenarios for spectrum supply and demand in the 470–862MHz band.

The economic impact modelling conducted during the study is based on existing research on the economic benefits of the digital dividend, plus other sources of information, primarily on costs. The modelling is necessarily top-down; that is, we do not attempt to model individual Member States in detail.

The spectrum supply scenarios refer to sets of decisions made by Member States regarding what different parts of the 470–862MHz band could be used for. They focus on the split between DTT and wireless broadband as a first approximation in assessing the impact of different allocations.

Our Reference Scenario assumes that:

- 16 Member States will identify a 790–862MHz sub-band: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Ireland, Italy, Luxemburg, Netherlands, Portugal, Slovenia, Spain, Sweden, UK
- 11 Member States will retain high-power DTT in the whole band: Bulgaria, Cyprus, Estonia, Greece, Hungary, Latvia, Lithuania, Malta, Poland, Romania, and Slovakia.

Note that the above assumptions do not pre-judge the outcome in each specific Member State – these are simply 'broad brush' assumptions that are required to facilitate our economic analysis. In practice individual Member States may adopt different approaches from what is assumed in the Reference Scenario.

We then model three spectrum supply scenarios, representing escalating levels of difference from the Reference Scenario.

- **Scenario 1** considers a situation in which the 790–862MHz sub-band is adopted throughout the EU for uses other than high-power uses, whilst 470–790MHz is used for high-power DTT.
- **Scenario 2** is an extension of Scenario 1 in which from 2018 high-power DTT is further constrained to a 'core' band, assumed to be between 470MHz and 694MHz for purposes of our modelling. The 790–862MHz sub-band and the resulting second sub-band between 470–694MHz are available for common or varied uses.
- **Scenario 3** is a radical scenario in which high-power DTT is cleared from the band from 2020, and cable, IPTV and satellite become the main television platforms. This scenario is clearly an extreme scenario that maximises the spectrum available for other uses, principally wireless broadband, and other major technologies and/or services that may emerge. This scenario is useful for comparative purposes and for understanding the sensitivity of our value estimates to the assumptions in our model but we note that realising this scenario would not only be challenging but also politically sensitive. Any decision to implement such a scenario in a Member State would need to be a political one.

These scenarios are illustrated in Figure 1.8 below.

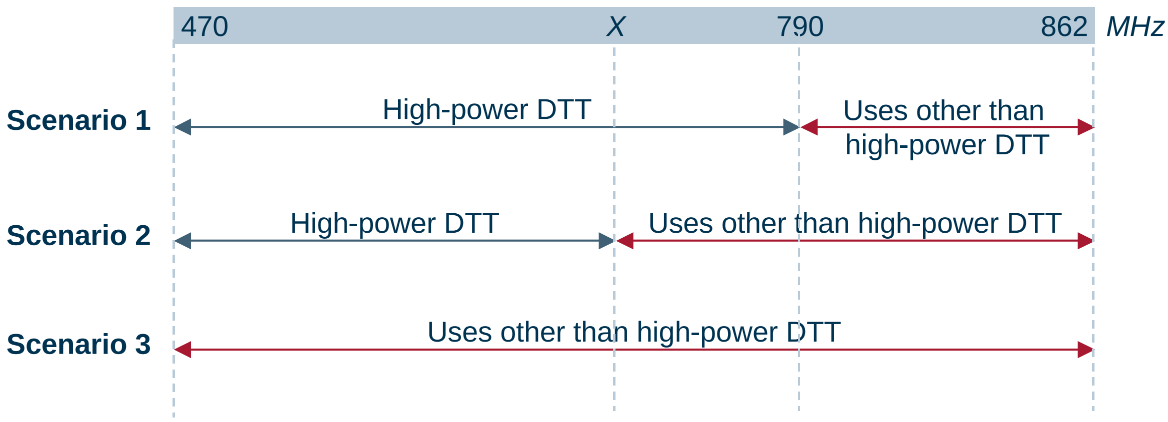

Figure 1.8: Broad supply scenarios for the 470–862MHz band [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

The scenarios for spectrum demand involve plausible but very different assumptions about the demand for spectrum from potential uses. In order to limit the number of combined scenarios, uncertainty in spectrum demand is assumed to be driven by uncertainty about consumer demand for services, rather than about technology and costs. Six overall scenarios for spectrum demand are used, as illustrated in Figure 1.9.

DTT \ Wireless broadband	Low	High	High with new use
Low	Scenario A	Scenario B	Scenario C
High	Scenario D	Scenario E	Scenario F

Figure 1.9: Broad demand scenarios for the 470–862MHz band [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

In calculating the economic impact of each combination of scenarios for spectrum supply and consumer demand, technology choice is modelled by assuming that operators deploy the standards and infrastructure that maximise the total (private) value that can be generated, based on currently known cost parameters.

1.3.3 Economic value of demand and supply scenarios

Section 13 presents the results of the modelling of the incremental economic value of the different scenarios. The types of costs and benefits captured in the model are summarised in Figure 1.10 below.

Incremental benefits	*Scenario 1*	*Scenario 2*	*Scenario 3*
No use prevented in the 790–862MHz sub-band in any Member State	✓	✓	✓
Increased value from economies of scale and roaming	✓	✓	✓
Greater certainty for manufacturers	✓	✓	✓
Additional benefits from spectrum beyond the 790–862MHz sub-band		✓	✓
Incremental costs	*Scenario 1*	*Scenario 2*	*Scenario 3*
Loss of DTT multiplexes	✓	✓	(✓)
Upgrade and changes to broadcasting networks	✓	✓	(✓)
Consumer switching costs – change in broadcasting networks	✓	✓	(✓)
Development of alternative free-to-view platform			✓
Consumer switching costs – alternative free-to-view platform			✓

Figure 1.10: Sources of incremental benefits and costs in supply scenarios [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

The modelling results are summarised in Figure 1.11 below, which presents the incremental private value generated by DTT (i.e. the value generated from using spectrum in the 470–862MHz band over and above the value that would be realised if a service was only provided by alternative means), wireless broadband and (where applicable) a new use yet to be determined, for each combination of spectrum supply and demand, relative to the Reference Scenario. For each demand scenario, the private value associated with the optimal supply scenario is highlighted in bold red.

Demand scenarios	*Incremental private value of supply scenarios relative to the Reference Scenario as of 2009*		
	Scenario 1 *(Sub-band for non-high-power DTT use introduced at 790–862MHz)*	***Scenario 2*** *(Second sub-band in addition to the 790–862MHz sub-band)*	***Scenario 3*** *(High-power DTT is cleared from the entire band)*
Scenario A *(DTT low, wireless broadband low)*	**EUR17 billion**	EUR13 billion	EUR1 billion
Scenario B *(DTT low, wireless broadband high)*	EUR44 billion	**EUR61 billion**	EUR51 billion
Scenario C *(DTT low, wireless broadband high with a new use)*	EUR44 billion	EUR75 billion	**EUR95 billion**
Scenario D *(DTT high, wireless broadband low)*	**EUR17 billion**	EUR12 billion	EUR0.2 billion
Scenario E *(DTT high, wireless broadband high)*	EUR44 billion	**EUR60 billion**	EUR50 billion
Scenario F *(DTT high, wireless broadband high with a new use)*	EUR44 billion	EUR74 billion	**EUR95 billion**

Figure 1.11: Summary of private value of demand and supply combinations [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

Note that detailed results for each combination of spectrum supply and demand is contained in Section 13.

There are a number of high-level observations that can be drawn from these results.

- The Reference Scenario generates less private value than our alternative supply scenarios, irrespective of what happens to demand for key services.
- The key drivers of private value are consumer demand forecasts for wireless broadband and other new services, rather than for DTT, since uncertainty over wireless broadband is greater and higher levels of demand for DTT can alternatively be realised by upgrading DTT technologies and deployment techniques.
- Generally, lower demand for wireless broadband and other uses favours fewer changes to the existing spectrum allocation, while higher demand favours allocations in which more of the band is cleared.
- There is no unambiguously preferable supply scenario.

The more specific conclusions for each scenario are as follows:

- ***Scenario 1 (high-power DTT is used in 470–790MHz, and a 790–862MHz sub-band is identified for a common use).*** A notable finding from the modelling of Scenario 1 is that clearance of a 790–862MHz sub-band could generate a net private value benefit based on national benefits and costs alone, even before taking account of the European dimension of benefits (coordinated interference management, improved roaming, and certainty and economies of scale for manufacturers). One interpretation of this result is that Member States not intending to adopt the 790–862MHz sub-band may not be currently planning their digital dividend spectrum allocations optimally, irrespective of the European dimension. However, this conclusion does not consider individual national circumstances such as legal and technical difficulties in clearing the upper part of the 470–862MHz band because of allocation decisions already made at GE-06; interference from countries outside the EU; and the cost of mitigating interference to cable networks. Some Member States may also have public policy grounds for allocating the entire band to high-power DTT not captured in the top-down modelling. Nevertheless, the scale of private value benefits from wireless broadband (even in the low-demand scenarios) is such that there would need to be compelling grounds for individual Member States *not* making any of the 470–862MHz band available for other services.

- ***Scenario 2 (high-power DTT is used in a core band, and two sub-bands are identified).*** Our modelling suggests that the case for adoption of a second sub-band (Scenario 2) is highly dependent on there being sufficient demand for wireless broadband or other services to justify the costs of replanning high-power DTT into a smaller part of the band. This is because the additional private value created by wireless broadband or other uses under Scenario 2 is limited to the incremental value over and above that generated by wireless broadband using the 790–862MHz sub-band. Further, clearance of the second sub-band would require a significant reduction in the spectrum available to high-power DTT, meaning that there must be a substantial reduction in DTT output and/or significant upgrades to DTT networks and consumer equipment.

- ***Scenario 3 (high-power DTT is not used in the 470–862MHz band).*** Scenario 3 is the most radical departure from the Reference Scenario, and should therefore be viewed as a more theoretical and somewhat extreme option. This is because it would involve clearing high-power use (i.e. traditional broadcasting via high power transmitters) from the entire 470–862MHz band by 2020. In this scenario, we have assumed that free-to-view services currently carried by DTT, including regional and local content, would continue to be offered using other platforms instead. In the most aggressive demand scenarios (C and F), Scenario 3 emerges as being more beneficial in terms of its contribution to private value, because of the greater availability of spectrum for new and valuable services. However, the quantitative modelling may underestimate the loss of value associated with eliminating high-power DTT, as it does not consider factors such as: the reduction in platform competition; consumer preferences for DTT and resistance to the adoption of other platforms; and the political costs and upheaval for broadcasters and consumers.

1.3.4 Options for EU-level action

Sections 14 and 15 identify and evaluate the options for EU-level action regarding use of the 470–862MHz band, leading to specific recommendations. They are divided into *high-level actions*, which influence the availability of spectrum, and *sector-specific actions*, which may influence relative demand for spectrum from potential uses.

The areas for potential high-level action considered in the report are:

- adoption of a 790–862MHz sub-band suitable for medium/low-power services including wireless broadband
- further clearance of high-power DTT from the 470–862MHz band, through either:
  - adopting a second sub-band, or
  - promoting the long-term clearance of the entire band (though we note that this is an extreme case that would require a political decision; it may only be possible in the longer-term and only in certain Member States)
- supporting the use of interleaved spectrum.

We also consider options for EU action for each of our seven categories of potential uses. These are actions that are either required to support the recommended high-level actions or are warranted in their own right.

The following sub-sections below provide a summary of the options for action and explains the rationale for each of our recommendations (which are reproduced in the grey boxes below). Note that for certain potential uses we concluded that no recommendations are required.

Actions supporting the adoption of a 790–862MHz sub-band

Our report concludes that there is a clear economic case for action to support a common sub-band, 790–862MHz, which could result in a private value benefit of EUR17 billion to EUR44 billion over the Reference Scenario, if the sub-band is adopted across the EU by 2015. There is also likely to be public value generated by the adoption of the sub-band, notably from the provision of wireless broadband to rural areas, although this must be considered against a loss in public value if the number of DTT programming channels is reduced in order to clear the sub-band. We believe that the adoption of a common sub-band across the EU could be achieved by 2015. Many Member States may adopt the sub-band sooner than 2015, but this is a realistic backstop date given that some Member States face specific challenges, such as the need to resolve the issue of high-power interference along the EU's eastern border.

We also conclude that there are no grounds to abandon technology and service neutrality principles (WAPECS). Specifying that the sub-band is used for a certain technology (e.g. wireless broadband FDD systems) could, in theory, maximise the benefits from economies of scale, however there is a risk that such technologies turn out to be non-optimal. Further, this action would be against the Commission's WAPECS concept. Overall, a technology-neutral award processes is likely to determine the best combination in each Member State. However, given that there is potential for high-power DTT to significantly restrict other uses (including wireless broadband) in the sub-band in neighbouring countries, we suggest that interference caused to neighbouring countries is restricted to no more than that from a medium-power use.

Clearance of high-power DTT from the sub-band (and possible clearance from more of the 470–862MHz band) will involve substantial investment by the current users in order to restructure their DTT networks. Since the benefits of clearance will accrue to others (most likely wireless broadband providers), the question of who should finance these refarming costs will arise. This is a matter for national governments to decide, and we therefore do not address it in our EU-level recommendations. However, as noted in Section 8.3, the fact that adoption of the sub-band is likely to generate public value suggests that there may be a role for public funding.

Recommended action 1: The 790–862MHz sub-band

All Member States are required to clear and award the 790–862MHz sub-band by 2015 in a format that enables it to be used for wireless broadband. Member States are encouraged to award the sub-band on a service- and technology-neutral basis, in accordance with the Commission's WAPECS principle.[7] To support these actions, technical restrictions should be in place to prevent emissions at borders exceeding medium-power thresholds.

Member States are free to design their own award processes, but these should not preclude the possibility of spectrum being used for wireless broadband using paired spectrum channels in line with the CEPT FDD band plan.

Where possible, Member States are encouraged to adopt the sub-band prior to 2015. To facilitate this action, Member States may be requested or obliged to share their plans publicly regarding the adoption of the sub-band.

Actions to clear further spectrum below 790MHz

In addition to the adoption of a sub-band at 790–862MHz, there is a possible economic case for *future* action to clear further spectrum below 790MHz. According to our modelling, adopting a second sub-band at 694–790MHz could generate up to EUR31 billion in additional private value across the EU, and, in our extreme case, total clearance could generate up to EUR51 billion. However, such benefits are uncertain, as they depend on there being strong growth in demand for wireless broadband and other future uses. Under our scenarios for lower growth in demand for wireless broadband, further clearance could in fact entail a EU-wide private value loss of up to

[7] Note that Member States may still directly award the sub-band for wireless broadband use if deviation from the EU's policy of service and technology neutrality can be justified.

EUR17 billion. In terms of public value, the case is likely to be similar. Further clearance of the band could generate additional public value from wireless broadband or other future as yet unknown uses. However, the loss of public value from DTT could be higher than if just the first sub-band was adopted, particularly in the case of total clearance of DTT from the band if the public value of DTT cannot be fully replicated on other TV platforms.

Accordingly, we conclude that it is premature to conclude whether there is an economic case for further clearance of digital dividend spectrum below 790MHz. Instead, we propose that the situation should be reviewed in the short to mid term (e.g. 2012–2014), by which time current market uncertainties may be resolved. For the avoidance of doubt, we suggest that such a review should not commit Member States to actually *implementing* these actions. We expect that full clearance of the band would require a political decision in addition to any economic case.

Recommended action 2: Further band clearance

There is insufficient information about future demand for wireless broadband and other services to currently make a decision on whether Member States should be encouraged to clear spectrum in addition to the sub-band at 790–862MHz. However, the possibility of action in the medium-long term to either adopt a second sub-band or to clear entirely the 470–862MHz band should not be ruled out.

We propose that the issue of further band clearance is reviewed again in short to mid term. This review should only take place once decisions regarding the first sub-band are largely resolved. Any review should consider both the likely evolution of demand for wireless broadband and other services, and the costs associated with clearance of high-power DTT and other incumbent users from a second sub-band or the entire band. The review should also consider what subsequent preparations would be required to facilitate the rapid and coordinated implementation of further spectrum clearance across Member States if an EU decision was made to proceed with the second sub-band or total clearance.

Some limited research into the two options for further clearance should be initiated ahead of this review, so as to reduce any future delay in implementation. Such research should: (1) identify the amount, frequency location and band plan(s) for any spectrum to be cleared; (2) investigate the logistics and costs of each option for clearance; and (3) review the measures necessary to ensure adequate provisions of incumbent services using other platforms or spectrum bands (e.g. any upgrades to other platforms necessary to maintain universal free-to-view TV services).

Actions concerning services currently offered in interleaved spectrum

The Commission needs to consider whether its policies for the digital dividend will support the adequate provision of suitable spectrum for interleaved uses (notably SAB/SAP and cognitive technologies). We conclude that there is no immediate shortage of interleaved spectrum for SAB/SAP, based on current DTT deployment plans and taking into account the possibility for EU-wide adoption of the 790–862MHz sub-band. Further, we do not think it is viable to reserve interleaved spectrum for specific uses beyond the short-term, as this may impede flexibility for future spectrum reorganisation. We note, however, that a requirement for action to safeguard SAB/SAP use may arise in the future, depending on plans for further spectrum clearance. Such actions may include encouraging SAB/SAP users to either migrate to more spectrally efficient equipment and/or to use spectrum outside the 470–862MHz band.

Recommended action 3: Interleaved spectrum

No action is currently required to encourage Member States to make sufficient interleaved spectrum available for SAB/SAP and/or other uses. However, any future review of options for further clearance of the band should consider the impact on users of interleaved spectrum (but no immediate action on interleaved use is required)

DTT

Our modelling shows that adopting more spectrally efficient technologies/topologies for DTT broadcasting will be necessary to some extent under all scenarios considered. We have identified four areas in which EU-level actions could be warranted to avoid delay in the adoption of these technologies/ topologies:

- creating specifications for DTT receivers
- adopting advanced DTT transmission technologies
- coordinating DTT deployment topologies
- brokering bilateral and multilateral negotiations on DTT replanning.

– *Creating specifications for DTT receivers*

At workshops conducted during the study, there was strong support from stakeholders for the introduction of common standards for DTT receiver performance, particularly with respect to minimum interference rejection standards and minimum performance of compression technologies.

In order to support our recommended action for the adoption of the 790–862MHz sub-band, we believe it would be beneficial to specify minimum interference tolerance/rejection standards for DTT receivers. Without such standards, the full use of the sub-band may be put at risk in some Member States or at least require the introduction of power limits that limit the efficiency and coverage of wireless broadband. The specifications should include measures that address the issue of interference from signals received in the adjacent channel and image channel (n+9).

Regarding compression standards, there appears to be wide backing for the adoption of more efficient standards, such as MPEG-4, across the EU (and specifically the H.264/MPEG-4 AVC variant). If the 790–862MHz sub-band is adopted, broadcasters that currently use MPEG-2 would benefit from migrating transmission to a more efficient compression standard such as MPEG-4 in order to avoid reductions in their transmission capacity. To facilitate such a migration, all MPEG-2 only receivers would need to be replaced by receivers that are compatible with more efficient compression standards.

In Section 15.2.1 we identify and quantify two main benefits that may result from including a high compression capability (such as MPEG-4 AVC or better) in all DTT receivers from 2012.

- Migrating DTT networks to an efficient compression technology (such as MPEG-4) may be required/attractive for many Member States in order to adopt the 790–862MHz sub-band. Encouraging more efficient receivers in the market could prevent a delay in the adoption of the sub-band. We estimate that a one-year delay reduces the value of adopting the sub-band by between EUR3.6 billion and EUR8.8 billion in net present value over 15 years.

- It would reduce the number of less efficient (MPEG-2 only) receivers that would need to be replaced in order to migrate to an advanced compression technology (such as MPEG-4). We estimate that the cost of such replacements would be reduced by approximately EUR700 million, on the assumption that the 15 Member States that currently only use MPEG-2 migrated to a more efficient technology by 2015.

Note that it would not be necessary for all Member States to adopt the same minimum compression technology. The most important aspect would be to enable the rapid realisation of the spectrum efficiency gains from an advanced compression technology if a Member State decided to upgrade its broadcasting infrastructure. If a critical mass of Member States were to choose the same minimum compression standard, this would provide further economic benefits by increasing the potential economies of scale for receivers incorporating the standard, therefore resulting in lower costs for consumers.

However, there may also be costs to requiring the inclusion of a more efficient compression technology in all DTT receivers.

- This requirement may increase the cost of producing receivers. We estimate that consumers who would otherwise have bought cheaper MPEG-2 receivers would spend EUR470 million more on more efficient receivers. However, this would be partially offset by EUR300 million, as consumers who would have bought more efficient receivers (e.g. incorporating MPEG-4 technology) anyway will benefit from reduced prices due to increased economies of scale.

More generally, there is a risk associated with requiring a specific technology. For example MPEG-4, or the H.264/MPEG-4 AVC variant, may not be the optimal choice of technology in the long term. Therefore, our recommendation is based on a requirement that all sold receivers meet minimum technology-neutral efficiency specifications. In this way, no single technology or standard is to be favoured over others, as was the case with the Commission's support of the DVB-H standard for mobile broadcast TV in the EU. Any technologies, MPEG-4 or otherwise, that either meet or exceed the minimum performance standard will be permitted. It would nonetheless be beneficial if the market/Member States were to converge on common technologies in order to maximise the economies of scale benefits leading to lower prices for consumers.

We understand that defining such technology-neutral minimum specifications may be challenging and therefore recommend that research be undertaken to establish, first, whether such a definition is possible, and secondly, what the exact technical parameters should be.

Recommended action 4: Specifications for DTT receivers

To facilitate an increase in the minimum spectral efficiency from DTT broadcasting, research should be conducted as soon as possible to define the parameters for the required minimum interference rejection standards and the minimum performance of compression technologies for DTT receivers. We suggest that the minimum compression performance is set to reflect the efficiency gains provided by the H.264/MPEG-4 AVC[8] standard.

All sold DTT receivers in the EU should be required as soon as possible to conform to these technology-neutral minimum interference rejection and compression performance standards.

Note that whilst this recommendation makes reference to a specific technology/performance standard, this is solely a means of facilitating the establishment of a realistic/achievable minimum efficiency standard – as such, a technology-neutral specification does not currently exist. The reference to a specific technology (H.264/MPEG-4 AVC) does not preclude an alternative technology being adopted (for example by an individual Member State), particularly in cases where such an alternative technology offers even greater efficiency gains.

– *Adopting advanced DTT transmission technologies*

Without any EU action, Member States may introduce new DTT transmission techniques, such as MPEG-4 and DVB-T2, over widely differing timeframes. EU-level action could facilitate the adoption of common techniques over a coordinated timeframe.

In parallel to creating an installed base of receivers capable of processing highly compressed transmission (such as for example MPEG-4 AVC as described above), requiring Member States to actually adopt these high compression standards in the short term would provide certainty for industry and may facilitate the adoption of the 790–862MHz sub-band, as it would make the reorganisation of DTT networks significantly easier. Requiring Member States to adopt DVB-T2 in the medium to long term would also accelerate the possibility of adopting a second sub-band across the EU. However, obliging all Member States to adopt a common timeframe for the adoption of specific transmission technologies may be detrimental to suppliers and consumers in some Member States, as they may be obliged to replace their existing equipment sooner than would otherwise have been the case. Indeed, the adoption of DVB-T2 may not be required if a second sub-band is not adopted. Further, other superior techniques may emerge in the interim.

8 Please note that there are many variants of the MPEG-4 standard. See Section 4.2.1 for further details.

A compromise approach would be to develop non-obligatory guidelines on minimum compression performance specifications (equivalent to H.264/MPEG-4 AVC), and encourage Member States to share their migration plans. Such guidelines, introduced in parallel with measures requiring new TV receivers to meet these specifications, could provide momentum across the EU for the accelerated adoption of more efficient technologies, while reducing the risks associated with compulsory action. A non-obligatory target of 2015 for the adoption of these standards would coincide with our recommendation above that all Member States are required to adopt the sub-band by 2015.

Recommended action 5: Adoption of advanced transmission technologies

Non-obligatory guidelines should be produced regarding the timeline for the adoption of minimum compression performance specifications for DTT transmission by Member States. As with our recommended action 4, we suggest that these should be equivalent to H.264/MPEG-4 AVC. This action will support the clearance of the 790–862MHz sub-band by 2015.

Member States should be requested to share their plans to migrate to more advanced transmission technologies so as to assist other Member States in developing their own plans.

Regarding receiver performance standards, note that the reference to a specific technology in the recommendation above does not preclude alternative technologies from being adopted, particularly if they provide further improvements in spectral efficiency.

– *Coordinating DTT deployment topologies*

Currently, few Member States have implemented SFNs for some of their national multiplexes and SFNs are mainly deployed at regional level. Significant efficiency gains could be realised through upgrading some or all DTT networks to national SFNs. However, such action would be expensive and disruptive to existing networks, so would likely only be desirable in the case that a second sub-band is cleared. In the meantime, we suggest that no definitive action should be taken regarding DTT deployment topologies but this should be reviewed alongside any decisions on further action to clear digital dividend spectrum.

– *Brokering bilateral and multilateral negotiations on DTT replanning*

Our report highlights potential concerns about the ability of Member States on a bilateral or multilateral basis to achieve timely consensus on the replanning of DTT necessary to facilitate the band clearance. In particular, negotiations may be complicated by asymmetries between Member States’ positions resulting from uneven GE-06 assignments.

These concerns suggest the Commission or other European bodies could play a more active role in promoting and brokering negotiations between Member States, as well as with non-EU countries. Regarding the 790–862MHz sub-band, there is evidence that bilateral and multilateral negotiations are having considerable success. However, there may be a call for EU-level brokering in relation to countries bordering the EU, so as to facilitate the timely realisation of the sub-band. Any decision to plan for or introduce a second sub-band would require much more complex coordination amongst Member States than is necessary for the first sub-band.

Recommended action 6: Brokering negotiations on DTT replanning

The Commission should make itself available as a neutral broker in negotiations between Member States, or between Member States and neighbouring non-EU countries regarding the re-allocation of spectrum in the 470–862MHz band.

Broadcast mobile TV

The main purpose of EU coordination of frequencies for broadcast mobile TV would be to ensure optimal economies of scale in networks and receivers. As mobile TV receivers using the DVB-H standard tune over a wide range (e.g. 470–750MHz for the DVB-H-enabled Nokia N96), the benefits would be limited to the cost saving realised by reducing this tuning range. A number of Member States have already deployed or made plans to deploy DVB-H networks using their existing GE-06 assignments. As these allocations are likely to be spread across the band, narrowing the tuning range may create migration and replanning costs for some Member States. Therefore, it is not obvious that guidelines for a smaller tuning range are either necessary or would be beneficial. Accordingly, we conclude that EU level action is not currently required.

Wireless broadband

One significant concern with respect to wireless broadband identified in our report is the relative inflexibility of spectrum requirements associated with current technologies. Notably, the requirement that FDD systems proposed for UMTS or LTS deployment use the same fixed duplex spacing in all Member States, in order to realise common economies of scale, means that FDD systems are very inflexible regarding frequency location.

In the future, if it were possible to redesign FDD systems so that they were more flexible in their use of spectrum, then this might allow (a) Member States to vary the amount of spectrum allocated to wireless broadband without compromising European scale economies; and (b) the expansion or contraction of wireless broadband spectrum during the course of a licence term in response to changing demand without the need to adopt further sub-bands. In turn, this may reduce the need for the coordination of spectrum availability at the EU level. Alternatively, the same benefits may be achieved if cellular systems changed from FDD to TDD technology, especially if frequency separation requirements between TDD users could be reduced.

Two potential actions to improve the flexibility in wireless broadband deployment in the 470–862MHz band are: (1) encouraging research into frequency agile wireless broadband systems, such as FDD systems that could operate with a variable duplex; and (2) prioritising access to spectrum for flexible systems. Neither of these actions are practical steps in relation to the timescale for the adoption of the 790–862MHz sub-band, but they may be for future potential releases of dividend spectrum. If greater flexibility can be introduced without unduly increasing technology costs, then the economic benefits of more efficient spectrum use could be substantial, especially for Member States whose optimal requirements differ significantly from the EU average.

Recommended action 7: Frequency agility of wireless broadband technologies
The Commission or other appropriate European bodies should work together with Member States to encourage research into the development of more frequency-agile technologies for wireless broadband (e.g. FDD systems with variable duplex).

SAB/SAP

The adoption of the 790–862MHz sub-band will require some Member States to relocate existing SAB/SAP users. In some cases, this may involve the relocation of dedicated nationally available channels. If this relocation is coordinated across Member States, economies of scale in equipment production across the EU may be realised more fully.

Our modelling suggests that the benefits from coordinating EU use of SAB/SAP in the same frequency channels would be modest (in the order of tens of millions of euros in discounted value). Further, given that many Member States do not currently have dedicated channels for SAB/SAP, it is not clear that there is a case for making such channels available in all Member States. Moreover, with the possible exception of the FDD duplex split in the 790–862MHz sub-band, the opportunity cost of making these channels available may be high. Therefore, action that requires all Member States to make a dedicated channel available appears unwarranted. Although providing guidelines on the frequency range for locating a dedicated channel appears to have few downsides, the benefits are small and the issue of location is complicated by national factors. We therefore conclude that it is more pragmatic to request that Member States considering relocating dedicated channels to share their plans.

Recommended action 8: Relocation of frequency channels for SAB/SAP
We propose that Member States considering relocating dedicated nationally available frequency channels for SAB/SAP (as part of their plans to clear the 790–862MHz sub-band) are requested to share their plans.

Public protection and disaster relief (PPDR)

We do not recommend any action at this stage to enable the allocation of spectrum in the 470–862MHz band for PPDR. This assessment reflects the high opportunity costs of reserving spectrum in either the 790–862MHz sub-band or another sub-band below 790MHz, the low certainty of demand for spectrum for PPDR in many Member States, and the potential scope for implementing PPDR in other lower opportunity cost spectrum bands (e.g. 300–400MHz or 2GHz).

Should a specific case for digital dividend spectrum to be set aside across Europe arise in the future, this could be considered as part of the review of the economic case for further band clearance under recommended action 2.

Cognitive technologies

The principal European dimension regarding cognitive technologies is the achievement of economies of scale, particularly for mass-market applications such as wireless local area networks. Some applications may also benefit from international roaming.

Guidelines regarding the technical and regulatory standards for cognitive technologies would encourage Member States to adopt common standards while ultimately allowing them to decide whether or not to permit cognitive technologies based on national considerations.

It would also be beneficial if Member States adopted common frequency ranges for devices that use cognitive technologies. This would provide certainty to equipment manufacturers over the tuning range their equipment should support, thus potentially accelerating the time to market.

We understand that European SMAs are contributing to WRC-11 agenda item 1.19 regarding regulatory measures for cognitive technologies via CEPT (CPG project team A). It may be appropriate for such common guidelines to feed into developing a Common European Position.

Recommended action 9: Cognitive technologies

Common guidelines should be developed regarding the technical parameters (including frequency ranges) and regulatory conditions for the introduction of cognitive technologies in the 470–862MHz band. These may feed into the EU's contribution to WRC-11 agenda item 1.19.

Member States are not required to either adopt this position nor permit cognitive technologies, these decisions remain at the national level.

Innovation reserve

In principal, part of the digital dividend spectrum could be identified as an "innovation reserve" to be used as a shared resource for experiments involving radio spectrum, or as an allocation option in the future. However, the benefits of such action appear modest relative to the opportunity cost of denying other uses access to spectrum. Further, we have not identified any obvious benefits to coordinating spectrum at EU level: experimental deployments are highly unlikely to benefit from any sort of economies of scale or roaming, irrespective of whether the spectrum used is harmonised across the EU. Finally, our understanding is that experimental uses should anyway be possible under current arrangements, for instance using interleaved spectrum on a regional basis.

We therefore recommend no EU-level action regarding this specific use.

Action to support possible further clearance of the band

Our analysis of options for sector-specific actions highlights a number of possible steps at an EU level that, although not warranted now, may have merit in the future if either a second sub-band is adopted or the entire band is cleared. These are actions to:

- encourage the compatibility of DTT receivers with DVB-T2 or other advanced transmission technologies
- encourage the adoption of DVB-T2 transmission or other advanced transmission technologies
- encourage the adoption of national SFNs for DTT provision instead of MFNs
- prepare for a GE-06 style conference to renegotiate DTT assignments if a second sub-band is adopted
- encourage SAB/SAP users to either migrate to more spectrally efficient digital equipment or to migrate to spectrum outside the 470–862MHz band.

Accordingly, we propose that any future review of preparatory actions for the further clearance of the 470–790MHz band also considers these sector-specific actions.

Recommended action 10: Action to support possible further clearance of the 470–862MHz band

The review of preparatory actions for further band clearance (recommended action 2) should consider a number of supporting sector-specific actions, including:

- encouraging DTT receivers to use advanced broadcast transmission technologies (such as DVB-T2) or to meet minimum bit rate specifications
- encouraging the adoption of advanced broadcast transmission technologies (such as DVB-T2) or adoption of minimum bit rate specifications for transmission technologies
- encouraging the adoption of national SFNs
- preparing for a GE-06 style conference to renegotiate DTT assignments
- encouraging SAB/SAP users to either migrate to more spectrally efficient digital equipment or to migrate to spectrum outside the 470–862MHz band.

1.4 Summary of Part D: Implementation roadmap, conclusions and recommendations

Sections 16 and 17 provide a roadmap for the implementation of our recommended actions and our conclusions.

We detail each of the activities, milestones and decision points in turn, before then discussing the main risks associated with the roadmap, which are:

- analogue switch-off is not complete in some Member States by 2012, thus delaying the adoption of the 790–862MHz sub-band
- multilateral negotiations to clear the 790–862MHz sub-band take longer then expected, thus delaying the adoption of the sub-band

- preparatory action for the potential adoption of the second sub-band/clearance of the band does not occur quickly enough to meet the proposed timescales
- it is not possible to produce technology-neutral minimum compression performance specifications.

Finally, we identify further technical work that we recommend takes place:

- technical research to determine the permissible emissions at border areas for the 790–862MHz sub-band
- research regarding either the adoption of a second sub-band or the clearance of high-power DTT from the entire band. This should include:
- size, frequency location and band plan for a second sub-band
- the costs and feasibility of the necessary upgrades to other TV platforms to maintain universal free-to-view TV services
- research to specify required technical receiver standards (minimum compression performance and interference rejection)
- research into frequency-agile technologies is to be encouraged
- common specifications are developed for parameters for the introduction of cognitive technologies
- further work is undertaken, potentially by CEPT, to assess how widespread the issue of interference to cable networks may be in individual Member States and the costs of resolving any harmful interference problems.

Figure 1.12 and Figure 1.13 below provide our proposed timeline for the implementation of the high-level and sector-specific recommended actions.

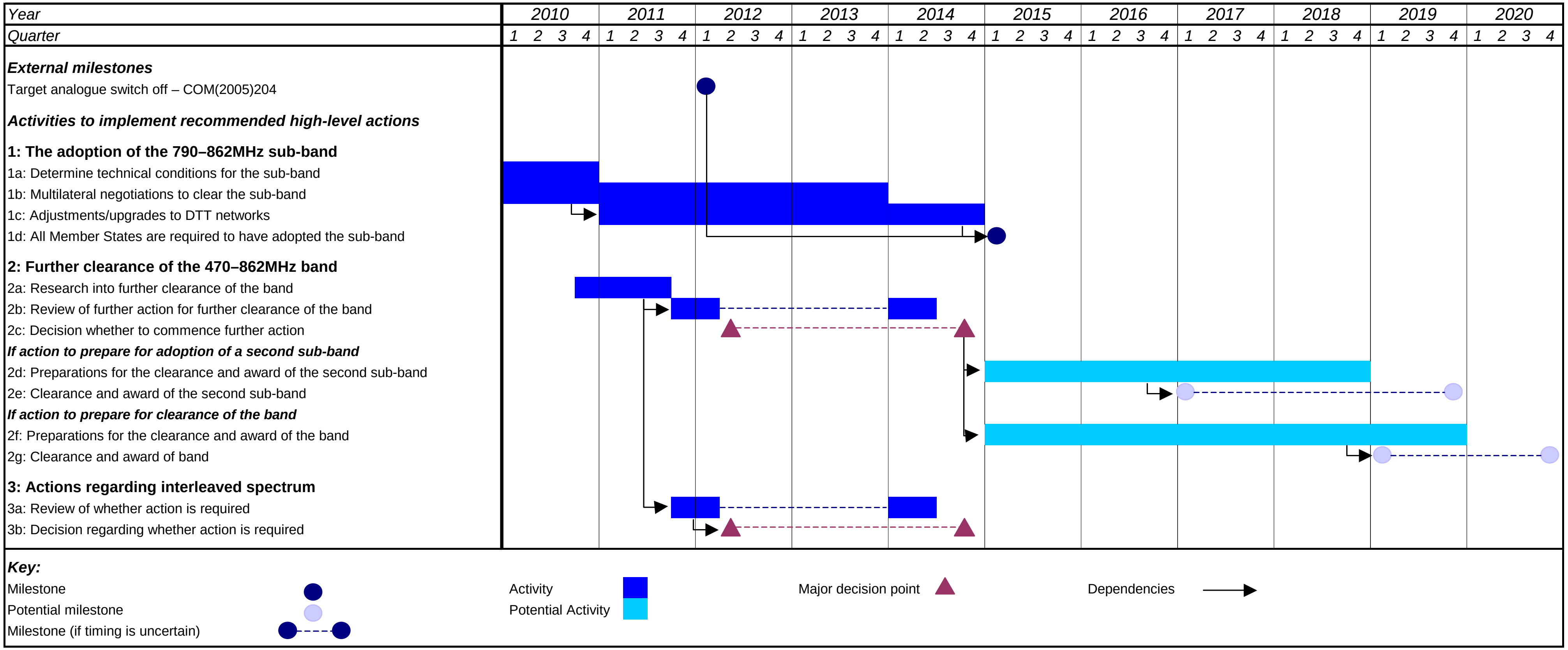

Figure 1.12: Implementation timeline for the recommended high-level actions [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

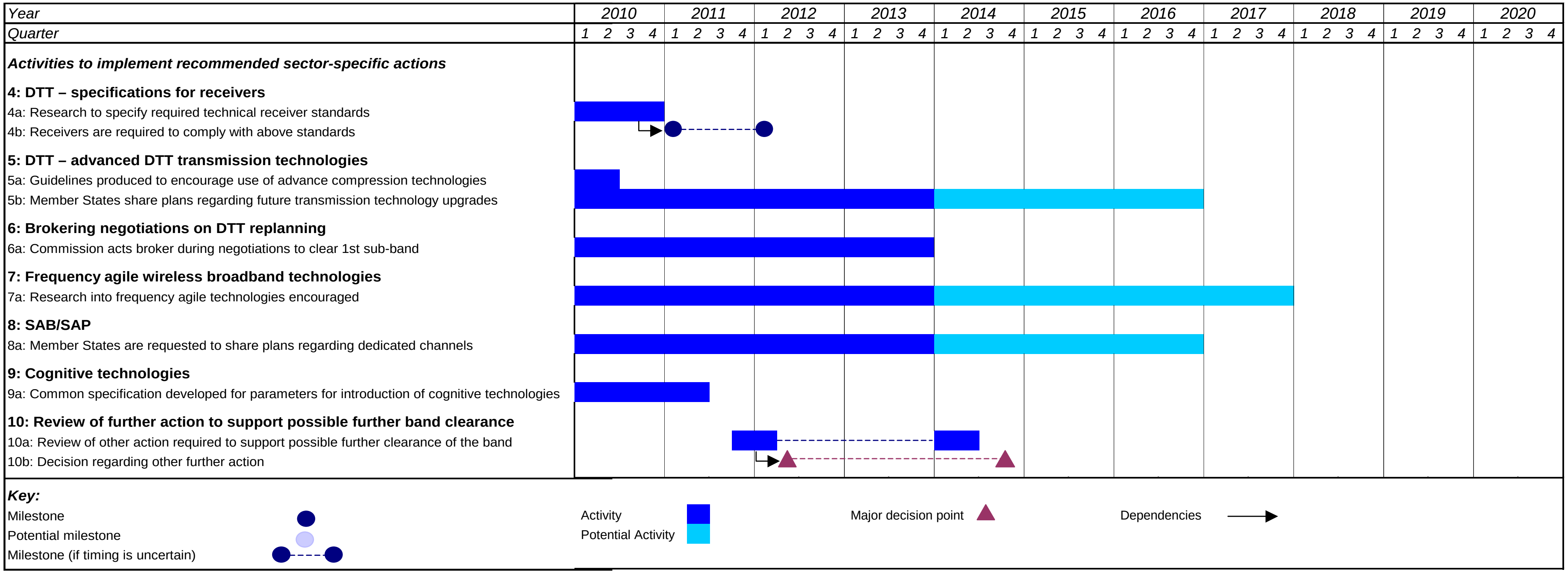

Figure 1.13: Implementation timeline for the recommended sector-specific actions [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

2 Introduction

This report has been prepared by a consortium comprising Analysys Mason Limited, DotEcon Limited and Hogan & Hartson LLP (‘the consortium’) on behalf of the Information Society and Media Directorate General of the European Commission (‘the Commission’) and provides a summary of the work undertaken by the consortium in relation to the study called “ ‘Exploiting the digital dividend’ – a European approach”.

2.1 Objectives of and approach to the study

The principal objectives of the study were firstly to ascertain what action needs to be taken at the European Union (EU) level (over and above actions that can be/are likely to be undertaken by individual Member States) to ensure that the benefits of the digital dividend are maximised across the EU; and secondly to develop a roadmap for the implementation of any identified action(s).

In order to achieve these objectives, we carried out five main activities, summarised in Figure 2.1 below.

Activities	***Summary of key tasks***
Inventory of national situations	• Desk-based research • Questionnaire and telephone interview programme • Research on international markets
Investigate key technical and commercial/economic constraints	• Technology trends • Interference management constraints and constraints linked to treaties
Scenarios for an EU coordinated approach	• Identification of alternative approaches, considering national situations • Cost/benefit analysis and impact assessment of approaches • Review and refinement of proposed options with Member States
Socio-economic analysis	• Review of existing economic studies • Stakeholders’ Hearings/Member States’ workshop • Demand for spectrum for alternative uses • Quantitative and qualitative assessment of alternative uses
Final recommendation and proposed roadmap	• Detailed impact assessment • Implementation plan including timeline • Recommendations for any additional technical work

Figure 2.1: Activities undertaken by the consortium [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

A key component of our approach was input from Member States and industry stakeholders. In order to gather this input, three events took place during the course of the study.

- On 6 March 2009, the Commission convened Stakeholders' Hearings in Brussels in order to understand the views of industry. A summary of the main views expressed is provided in Annex E of this report.
- In conjunction with the Radio Spectrum Policy Group (RSPG) Working Group on the digital dividend, the Commission hosted a workshop on 15 April 2009 for Member States. This workshop provided an opportunity for Member States to participate in an open exchange of views on the scope, nature and timeframe of any action. A summary of the main views expressed is provided in Annex F of this report.
- On 26 June 2009, the Commission hosted a second workshop for Member States. This workshop allowed the consortium to present the socio-economic analysis conducted since the first Member States' workshop as well as a revised set of recommendations. A summary of the main views expressed is provided in Annex G of this report.

We would like to thank all those organisations and individuals who have contributed to the study by participating in the Stakeholders' Hearings, the Member States' workshops, or by providing other forms of input to the study (e.g. written submissions). This input has been invaluable to the study team and has informed our recommendations.

2.2 Structure of this report

This remainder of this report is structured in four parts (Parts A–D), plus annexes.

Part A provides background information about the digital dividend spectrum:

- Section 3 defines the digital dividend and explains why it is important
- Section 4 provides an overview of the potential uses of the digital dividend, and then discusses relevant future service or technological developments
- Section 5 explains the responsibilities of national and European bodies for allocating and assigning the digital dividend spectrum
- Section 6 assesses the situation regarding the digital dividend across Member States, as well as in other key markets.

Part B examines the factors influencing the use of the digital dividend:

- Section 7 provides an overview of the spectrum requirements of each potential use and the channel compatibility issues
- Section 8 examines the national and EU policies that relate to the digital dividend
- Section 9 assesses the incremental value (both private and external) that each use could generate
- Section 10 assesses the spectrum demand for each use under a range of market scenarios.

Part C is dedicated to the rationale and options for EU-level action:

- Section 11 explains why there is a European dimension to future decisions regarding the digital dividend, and what principles should be considered when considering EU-level action
- Section 12 presents a small number of broad scenarios regarding the future use of the band, ranging from the evolutionary to the revolutionary
- Section 13 contains a quantitative and qualitative evaluation of the broad scenarios identified in Section 10 in order to understand which will provide the greatest short- and long-term benefits
- Section 14 identifies options for EU-level action in order to encourage the most desirable outcome identified in Section 11
- Section 15 provides a socio-economic analysis of the options identified in Section 12, before recommending preferred action(s).

Part D presents an implementation roadmap and our conclusions from the study:

- Section 16 provides an implementation roadmap for our recommended actions
- Section 17 presents our conclusions and a summary of our recommendations.

Annexes

- Annex A is an inventory of national situations affecting the digital dividend in Member States
- Annex B is a review of the situation regarding the digital dividend in neighbouring European countries
- Annex C is a review of the situation regarding the digital dividend in non-European countries

- Annex D is a glossary of terms used in this report
- Annex E is the summary of the Stakeholders’ Hearings on 6 March 2009, as issued on 22 April 2009
- Annex F is the summary of the first Member States’ workshop on 15 April 2009, as issued on 5 May 2009
- Annex G is the summary of the second Member States’ workshop on 26 June 2009, as issued on 15 July 2009.

Part A: Background

3 What is the digital dividend?

In this section we introduce the UHF band, including the 470–862MHz band, and discuss its key attributes, explain the digital switchover then define the digital dividend and explain why it is important.

3.1 An introduction to UHF including the 470–862MHz band

The UHF band ranges from 300MHz to 3GHz. Since the Stockholm Agreement in 1961, analogue terrestrial TV signals have been transmitted mainly using 470–862MHz (known as UHF bands IV and V), although in the vast majority of countries in Europe, 174–230MHz (VHF band III) has also been used for analogue terrestrial TV.

The UHF band, in particular 470–862MHz, is widely regarded as some of the most valuable radio spectrum. This is because it provides a balance between coverage, capacity and ease of equipment design, which is highly desirable. This frequency range has strong propagation characteristics meaning that signals travel further and penetrate deeper into buildings than for higher frequencies. Antenna size for 470–862MHz is reasonable and internal antennas can be developed for small devices such as cellular handsets – this is not the case for lower frequencies.

The radio spectrum is illustrated in Figure 3.1 below, highlighting the UHF band, in particular 470–862MHz.

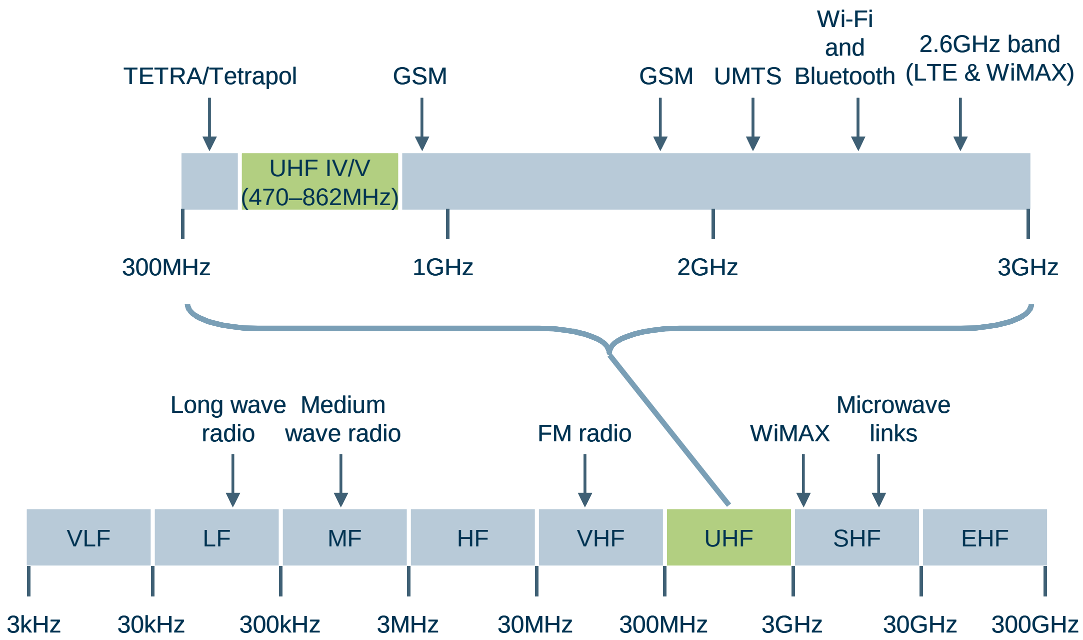

Figure 3.1: The radio spectrum, particularly UHF bands IV and V, with current (and future) major uses highlighted[9] [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

As illustrated in Figure 3.2 below, the 470–862MHz band is currently divided into 49 spectrum channels of 8MHz. These channels are numbered 21 to 69, with Channel 21 at 470–478MHz, and Channel 69 at 854–862MHz. Band IV comprises Channels 21 to 34 (470–582MHz), while Band V comprises Channels 35 to 69 (582–862MHz).

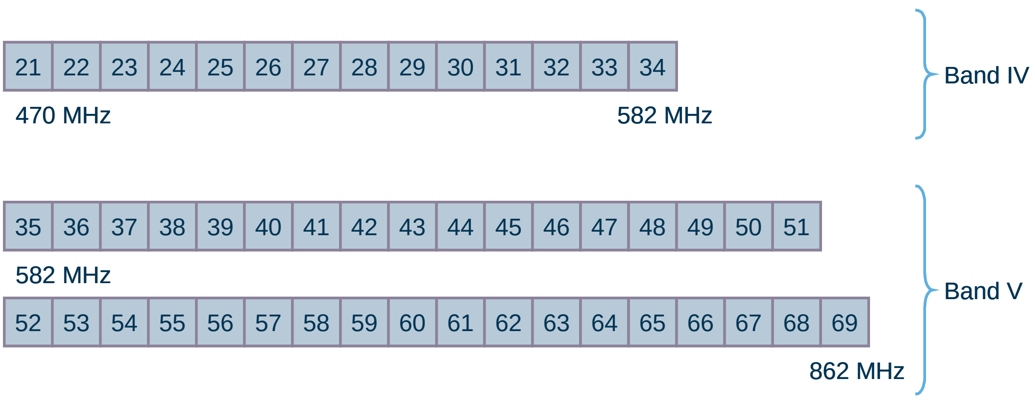

Figure 3.2: Band plan of 470–862MHz [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

9 Specific frequency bands used for the uses illustrated in this diagram are as follows: TETRA/TETRAPOL (380–400MHz), GSM900 (880–960MHz), GSM1800 (1805–1880MHz), UMTS (1900–1980MHz, 2010–2025MHz and 2110–2170MHz), Wi-Fi, Bluetooth (2400–2483.5MHz), WiMAX (3.3–3.5GHz) and the 2.6GHz band (2500–2690MHz).

3.2 The digital switchover

The switchover from analogue to digital terrestrial TV (DTT) frees up a significant amount of spectrum (primarily in the 470–862MHz band) due to the more efficient use of spectrum by digital broadcasting technologies. This so-called ‘digital dividend’ provides an unprecedented opportunity in view of:

- the wide range of potential uses of the freed spectrum, including additional DTT (including high-definition (HD) services), cellular/wireless broadband networks (especially in less densely populated areas), broadcast mobile TV networks, wireless broadband networks for PPDR users and low-power uses (e.g. wireless microphones and short-range data devices)
- the amount of spectrum that is potentially available (theoretically up to around 320MHz[10])
- the superior propagation characteristics of the band
- the fact that this spectrum could be made available in all Member States at a similar time, raising the possibility of its use becoming harmonised.

Member States have either completed, are in the process of, or are planning the transition from analogue to DTT broadcasting; Most Member States are planning to complete this transition by 2012. Digital technologies (assuming DVB-T and MPEG-2 technologies are used) enable approximately six to eight standard-definition (SD) TV programming channels to be broadcast in the same amount of spectrum required for just one analogue TV programming channel. As a result, just a fraction of the spectrum will be required to broadcast the existing analogue TV programming channels digitally. Note that newer technologies are likely to be even more spectrally efficient. For example the use of MPEG-4 compression technology rather than MPEG-2 may result in a 100% increase in efficiency (see Section 4.2.1 for further details).

3.3 Definitions of the digital dividend

The term ‘digital dividend’ remains subject to interpretation.

- Ofcom (UK) defines the digital dividend as being the spectrum available over and above the spectrum required to deploy six DTT multiplexes across the UK.
- In France, the government defines the digital dividend as the spectrum available over and above the spectrum required to deploy the seven current DTT multiplexes across the country (six DTT multiplexes and one broadcast mobile TV multiplex).
- Malta has not identified a digital dividend at all.

10 Assuming an MFN network is used, around nine spectrum channels are required to support previous analogue services, meaning that around 40 of the 49 spectrum channels can be released.

The definition suggested by the Commission, and used in this study, is:

"… the spectrum over and above the frequencies required to support existing broadcasting services in a fully digital environment, including current public service obligations".[11]

In other words, the digital dividend should refer to all *additional* spectrum that is released as a result of migrating only the existing analogue TV programming channels to digital.

In almost all Member States the existing national analogue TV programming channels could be carried on one digital multiplex, only Cyprus and Poland have more than six national analogue TV programming channels. This means that the digital dividend could, in theory, be around 320MHz for most Member States. The availability of such a large amount of highly valuable spectrum is a rare occurrence.

3.4 Why is the digital dividend important?

The digital dividend provides an unprecedented opportunity not only because the spectrum is suitable for a wide range of high-value potential uses, but also because of the amount potentially available, its desirable propagation characteristics, and the opportunity to harmonise use. Such high-quality spectrum is a scarce resource. The collective amount of spectrum needed for all potential uses is likely to exceed the amount of spectrum actually available in the digital dividend.

The digital dividend also provides a unique opportunity to generate economic, social and cultural benefit throughout the EU. Estimates in other studies suggest that the potential value (including both private and external) that users could generate from this spectrum could be large.

- In a study for ARCEP[12], Analysys Mason and Hogan & Hartson estimated that six DTT multiplexes in the 460–862MHz band could generate EUR37 billion of economic value to France, while wireless broadband services could generate EUR26 billion.

- Spectrum Value Partners estimated that broadcasters will generate between EUR750 billion and EUR850 billion in net present value throughout Europe using the 460–862MHz band, while mobile operators could generate from EUR63 billion to EUR165 billion.[13]

A more detailed review of the value of the digital dividend, including these two studies, is included in Section 9 below.

11 COM(2007) 700 final, Commission of the European Communities, (13 November 2007) "Reaping the full benefits of the digital dividend in Europe: A common approach to the use of the spectrum released by the digital switchover".

12 Analysys Mason and Hogan & Hartson for ARCEP (2008), "Valorisation du dividende numérique".

13 Spectrum Value Partners (March 2008) "Getting the most out of the digital dividend".

One important proposed use for digital dividend spectrum is wireless broadband. "Broadband for all" is a primary objective of the EU's i2010 policy framework.[14] This objective includes bridging the 'digital divide' between areas that have limited or no broadband coverage and those that have access to high-speed broadband (i.e. ensuring everyone is able to access the same digital services). Rural areas typically fall into the former category and urban areas into the latter.

Wireless systems are likely to be a more cost-efficient solution to providing high-speed broadband services to rural areas than fixed networks. The 470–862MHz band is particularly suited to providing wireless broadband to rural areas due to its favourable propagation characteristics, meaning that fewer base stations are required than for a higher frequency service. In addition, the Commission's European Economic Recovery Plan identifies high-speed broadband as a priority spending area for the Commission and Member States, and urges Member States to endorse its existing proposals "to free up spectrum [in the 470–862MHz band] for wireless broadband."[15]

Major economies competing with the EU have made rapid progress on making digital dividend spectrum available for alternative uses. An example is the 700MHz award in the USA in early 2008, which will predominantly be used to offer wireless broadband services, and may also be used for broadcast mobile TV and by the emergency services. It is therefore important for Member States to collaborate in order to maximise the potential benefits from the digital dividend, as this will enable the EU to maintain its competitive position. This is particularly relevant given the current economic downturn.

In addition, some, and arguably all, of the potential uses given in Section 3.2 provide public value. In other words, they provide a broader contribution to society than would be accounted for in an assessment of private value.[16] For example, services may contribute to a better-informed democracy, higher educational standards, public safety or a more inclusive society. These services may also play important roles in supporting public policy goals. For example, by using the digital dividend many of these services could help to bridge the digital divide by ensuring that high-value services (including TV and broadband) are available in rural areas.

Member States currently have a range of approaches to the digital dividend and are proceeding at varying paces. Some Member States have yet to develop plans for the digital dividend while others have specific proposals for future use. Such plans range from continuing to use all of the digital dividend for broadcast TV services, to allowing market forces (via an auction) to determine the future use of the spectrum.

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14 "A European Information Society for growth and employment".

15 COM(2008) 800 final, p.16. (26 November 2008) "A European Economic Recovery Plan', Communication from the Commission to the European Council".

16 Private value is defined as producer surplus plus consumer surplus, and excludes sources of external value (including public value).

EU-level coordination would bring significant economic, social and cultural benefits to the Community as a whole, as well as to individual Member States. Conversely, there is a risk that significant benefits could be foregone if Member States pursue varying approaches, particularly given:

- economies of scale are critical for many potential uses of the digital dividend (e.g. mobile handsets, DTT receivers)
- there may be benefits from international roaming and interoperability for many potential uses (e.g. roaming on mobile phones or use of public safety services across borders)
- the significant requirement for extensive cross-border coordination in order to manage interference resulting from high-power transmissions (e.g. broadcast TV).

The '**European dimension**', is the term used in this report for the rationale for EU-level action. Such action may be taken in order to meet EU policy goals, or to increase the total benefit to Member States over and above that which would be realised if Member States took uncoordinated action.

4 What could the digital dividend be used for?

In Section 3 we introduced a number of potential uses of the digital dividend. These vary widely, ranging from high-power uses such as DTT to low-power uses such as services ancillary to broadcasting and programme making (SAB/SAP). Further, the services that these uses provide and the technologies on which they rely, are rapidly evolving. In this section we provide an overview of each potential use, then discuss relevant future service or technological developments.

4.1 Overview of prospective uses

The principal potential uses for the digital dividend that we have identified are:

- digital terrestrial TV (DTT)
- broadcast mobile TV
- commercial wireless broadband, both to fixed locations and to mobile devices
- wireless broadband for public protection and disaster relief (PPDR)
- services ancillary to broadcasting and programme making (SAB/SAP).

Note that in some instances these overlap, for example wireless broadband for commercial users is very similar to that for PPDR users. However, there are different requirements from these distinct users; for the purposes of this study we have therefore considered them separately. In some respects DTT and broadcast mobile TV are also similar as they are both broadcast linear TV services to receivers. However, the requirements for the two uses are very different, most notably broadcast mobile TV requires the service to be available whilst moving – again, we have considered them separately.

We have also considered two further ‘uses’ of the digital dividend spectrum: cognitive technologies and an innovation reserve. Neither of these are strictly services or uses themselves. In the case of cognitive technologies, they a specific family of technologies that facilitate the provision of other uses, potentially including some of those uses identified above. An innovation reserve is spectrum reserved to enable the development of new technologies and services. For the purposes of this study we have considered both of these as uses of digital dividend spectrum in its broadest sense, although we take into account that there may be different issues to consider compared to the above uses.

During the first Member States’ workshop it was noted that there may be a wide range of other uses of the digital dividend (e.g. military use). However, we believe that the uses identified above are most likely, so this study focuses on these uses. Note that other than SAB/SAP and services using cognitive technologies, no other services that use interleaved spectrum were identified during the Stakeholders’ Hearings or Member States’ workshops.

4.1.1 Digital terrestrial TV (DTT)

Description of the services provided by this use

A potential use of the digital dividend is the deployment of additional DTT multiplexes to provide additional SDTV or HDTV programming channels (either free-to-view or on a subscription basis). Services could be national, regional or local.

Additional TV programming channels would increase the relative attractiveness of the DTT platform in Member States, compared with alternative platforms, such as cable, satellite or IPTV.

Technologies used to provide this service

A DTT multiplex is essentially a 'pipe' for the transmission of programming channels. The bit-rate capacity of a DTT multiplex depends on the technologies used. To date, the DVB-T standard has been used in Europe, which enables bit rates between 8Mbit/s and 27Mbit/s, depending on the modulation level used (e.g. QPSK-2/3 or 64QAM-3/4). DVB-T2 is a new DTT standard under development that will be able to offer higher bit rates (please see Section 4.2.1 below for a more detailed discussion of DVB-T2).

In principle, a multiplex can deliver any picture quality, including HDTV, providing that the services fit the available channel capacity and are receivable at a satisfactory bit error rate.

There are currently two main compression technologies that are used for DTT: MPEG-2 and MPEG-4. Using MPEG-2, an SDTV programming channel can be can be carried at 3.2Mbit/s.[17] MPEG-4 is approximately twice as efficient as MPEG-2. A more detailed discussion regarding MPEG-2 and MPEG-4, and the number of TV programming channels that a multiplex can carry using each, is included in Section 4.2.1 below.

Applicable frequencies within the 470–862MHz band

Frequencies available for DTT multiplexes in Member States were defined during the ITU Regional Radio Conference in 2006 (GE-06, described in more detail in Section 5.2 below), during which frequency plans were defined in order to allow Member States to deploy at least six DTT national multiplexes each without causing cross-border interference.

Note, the GE-06 framework does permit negotiations between Member States on a bilateral basis in order to find additional frequencies that can be used for DTT (in order for instance to increase the number of DTT multiplexes).

17 Ofcom (2007), "Review of DTT HD Capacity Issues".

DTT networks can be deployed using either multi-frequency networks (MFNs, which means that multiplexes use different frequencies at each transmitter site across the Member State), single frequency networks (SFNs, which means that the same frequency is used across large regions or the entire Member State) or a combination of the two. Traditionally, Member States have deployed MFNs (including when terrestrial TV was analogue only). This has meant that the whole of the 470–862MHz band has been used for TV.

Alternative frequency bands and delivery platforms

It is difficult to use other frequency bands outside the 470–862MHz band for DTT services because existing consumer equipment (e.g. aerials, set-top boxes) only works within 470–862MHz. Further, the use of alternative frequency bands may require additional TV transmitters to be deployed.

In theory 174–230MHz (VHF band III), which in many Member States was used for analogue services, could be used for DTT. However, digital consumer equipment is not currently available for this band. This band is now used in many Member States for other broadcast services such as digital audio broadcast (DAB) or digital multimedia broadcast (DMB).

Digital TV can be (and is currently) delivered over technologies other than DTT (e.g. cable, satellite, IPTV), but there are coverage limitations to each of these alternatives. Cable and IPTV coverage is typically poorer than DTT in rural areas. Satellite platforms typically have almost total coverage, other than in locations that are shadowed from the signal, or where it is not possible or allowed to erect a satellite dish. Some argue that using the digital dividend for DTT would enhance the attractiveness of the terrestrial platform over alternative delivery technologies, thus increasing competition. This could beneficially constrain prices in countries where alternative delivery technologies dominate.

Transmission characteristics

DTT services are mainly operated using high-power, one-way transmission. Typical DTT transmitters operate in the range 50W to 20kW. Taking into account antenna gains, a typical EIRP (effective isotropic radiated power) would be 50dBW. The height of a major broadcast transmission tower can be anything from 60 metres to over 300 metres (although relay transmitter sites are usually smaller), which contributes to the very wide coverage area of a broadcast transmitter.

Note that local DTT services may operate at significantly lower power, as it may not be necessary for these services to be transmitted to large areas.

4.1.2 Broadcast mobile TV

Description of the services provided by this use

The digital dividend could also be used to provide broadcast mobile TV services. Broadcast mobile TV is a linear, multicast (sent to many devices), multi-channel service in a format similar to non-mobile broadcast TV.

This service is different to unicast mobile TV (e.g. mobile TV over 3G networks). Unicast mobile TV is streamed (sent to one device) over the mobile operator's UMTS or HSPA network (for example Orange World TV's UMTS service in the UK).

Technologies used to provide this service

Such a service would require dedicated mobile broadcast networks, which are currently available in only a few Member States, including Austria, Finland, Italy and the Netherlands. Broadcast mobile TV services can be provided using a number of technologies including:

- *Mobile reception using DVB-T*
  - Whilst DVB-T was originally designed for stationary and portable reception, mobile reception is also possible. However, usually the coverage of a DVB-T network needs to be improved in order to enable acceptable mobile reception. Typically, reception is better using rooftop antennas than portable or mobile receivers, due to the lower antenna gain and height. The use of smaller cells in in-fill transmitters can overcome this. Recent technical developments have also made mobile reception of DVB-T easier – for example, it is understood that German mobile operators introduced handset models with DVB-T reception for the Euro 2008 football championship.
- *Digital Video Broadcasting for Handhelds (DVB-H)*
  - In March 2008, the Commission adopted a strategy favouring the take-up of mobile TV across Member States.[18] The strategy is based on a common EU standard for mobile TV: DVB-H networks have already been deployed in the 470–862MHz band in a number of Member States, including Austria, Finland, Italy and the Netherlands. DVB-H builds on the DVB-T standard and is specifically designed to improve mobile reception by overcoming multi-path channel effects.

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18 See: http://ec.europa.eu/information_society/tl/industry/broadcasting/mobile/index_en.htm.

- *Digital Multimedia Broadcast (DMB)*
  - DMB builds on the DAB standard developed for digital radio transmission. While there are no live DMB networks in the EU at present, trials have been undertaken in a number of countries. It is typically designed to operate in frequency bands designated for DAB i.e. 174–230MHz and 1452–1492MHz (L-Band).
- *MediaFLO*
  - This is Qualcomm’s proprietary technology. Qualcomm claims that MediaFLO can either offer more channels in the same spectrum (e.g. 30 compared to 15–20 with DVB-H in a 8MHz channel) or can offer an equivalent number of channels using less spectrum than DVB-H.

Applicable frequencies within the 470–862MHz band

In order to ensure sufficient frequency separation with GSM in the 900MHz band (to support the simultaneous use of broadcast mobile TV and GSM/3G), mobile TV providers typically prefer frequencies in the low to middle part of the 470–862MHz band (below 750MHz). Indeed the tuning range of many DVB-H-enabled handsets, including the Nokia N96, is 470–750MHz, i.e. the entire part of the band below 750MHz.

Alternative frequency bands and delivery platforms

The main alternatives to using 470–862MHz spectrum for a dedicated broadcast mobile TV network are 174–230MHz and 1452–1492MHz. However, broadcast mobile TV networks would benefit more from the balance between range of coverage and antenna size of the 470–862MHz band. For this reason, 470–862MHz is regarded as the most suitable frequency range for the deployment of broadcast mobile TV networks.

Another option is the use of a hybrid satellite/terrestrial broadcast mobile TV network, where the satellite network provides coverage in rural areas whilst the terrestrial network provides coverage in more densely populated areas where satellite reception may be problematic. The DVB-SH standard (Digital Video Broadcasting – Satellite services to Handhelds) has been developed (from the DVB-H standard) to support such a hybrid network operating in frequencies below 3GHz (including the 470–862MHz band). There is currently great interest in the use of S-band frequencies (2GHz) for such a hybrid network, following the recent award of assignments in this band by the European Commission to Solaris Mobile and Inmarsat (EuropaSat).

There are two alternative ways to deliver a terrestrial mobile TV service.

- Streamed over UMTS, HSPA and, in the future, Long Term Evolution (LTE) networks. However, if take up of such services is high this may add significant capacity demand to such networks, and could be a more costly delivery option compared with broadcast technologies.
- Use multimedia broadband multicast services (MBMS), which is an enhancement of UMTS/HSPA/LTE networks and enables an operator to broadcast the same data to all users within a particular cell. The capacity set aside in the cell for MBMS cannot then be used for other purposes, such as voice telephony or other data services.

Transmission characteristics

Broadcast mobile TV services are mainly operated using medium-power, one-way transmissions. Mobile TV networks have characteristics more similar to a cellular network, in order to achieve a greater depth of coverage to handheld devices. Typical base station power levels are in the range of 30W to 1.5kW. Taking account of antenna gain, typical EIRP is around 30dBW, i.e. similar to a cellular network.

4.1.3 Commercial wireless broadband

Description of the services provided by this use

The digital dividend could be used to provide wireless broadband services to consumers, either to fixed locations or to mobile terminals. The favourable propagation characteristics of digital dividend spectrum mean that it could be used to increase rural coverage for both mobile and fixed broadband services. These characteristics also mean that it is more suited than higher frequencies to provide in-building coverage for mobile broadband. However, given the wide availability or potential future availability of higher-speed broadband via fixed networks, it is unlikely that wireless broadband systems will be a serious competitor for fixed broadband in urban areas.

Wireless broadband networks will also be able to offer mobile voice telephony services, although these are already offered using technologies such as GSM in other bands (e.g. 900MHz band). They may also be used to offer TV services, both to fixed locations and mobile terminals.

- As discussed in Section 4.1.2 above, broadcast mobile TV can be streamed over wireless broadband networks, or delivered using enhancements such as MBMS.

- It is also possible that fixed TV services could be delivered over wireless broadband networks. However, the speed and capacity constraints of such networks may mean that the delivery of multiple, HDTV programming channels is likely to be difficult.

Digital dividend spectrum could be used by one of three types of wireless broadband users.

- *Existing mobile operators*
  - The majority of mobile operators in Europe have access to higher frequency spectrum in which they can offer wireless broadband services, notably the 2.1GHz band. The 2.6GHz band has also been awarded in Norway and Sweden, and is likely to be awarded in most Member States in the next two years. To date, most mobile operators have only deployed wireless broadband technologies in urban areas. Access to lower frequency spectrum, such as the digital dividend, but also the 900MHz band, would enable them to roll out these services to rural areas.
- *Existing fixed wireless broadband operators*
  - Fixed wireless broadband operators in Europe typically use the 3.4GHz band, though some may use 2.6GHz spectrum once it has been awarded. Lower frequency spectrum would provide two main benefits: it would reduce the cost of deployment in rural areas, and lower frequency spectrum is more suited to offering mobile services than the 3.4GHz band (though this may also be achieved using the 2.6GHz band).
- *New entrants*
  - New wireless broadband operators could enter the market using digital dividend spectrum alone. However, they may need more spectrum in this band than existing operators, as they will not have other, higher-frequency holdings to provide additional capacity in urban areas.

Technologies used to provide this service

There are two main technologies that could be used to provide this service.

- *UMTS (potentially with HSPA/HSPA+)/LTE*
  - UMTS is widely deployed across Europe in the 2.1GHz band and is being introduced in existing 2G cellular spectrum (e.g. 900MHz) in

some countries. If deployed with HSPA, an enhancement to UMTS, data services are offered at speeds of up to 7.2Mbit/s (actual speeds are usually somewhat lower). Speeds of 14.4Mbit/s may be possible in future releases of HSPA, and HSPA+ (a further enhancement of UMTS) will offer even higher speeds.

  – LTE is an evolution of the international 3GPP (Third Generation Partnership Project) to improve the current UMTS standard. LTE is likely to be significantly faster than current UMTS/HSPA networks, potentially up to around 100Mbit/s (though again, actual speeds are likely to be lower). LTE will offer time division duplex (TDD) and frequency division duplex (FDD) profiles, but is most likely to be deployed initially using the FDD profile.19 (See Section 4.2.3 below for a more detailed explanation of FDD and TDD.) LTE delivers better performance partially due to the use of larger channel bandwidths, and is expected to be deployed by mobile operators using channel widths up of to 2×20MHz. Versions of LTE are also likely to be available for smaller channel bandwidths (from as low as 2×1.25MHz), though using such channel sizes data speeds offered will be lower. Given the likely timescale for the release of the digital dividend, it is more likely that operators will deploy LTE rather than UMTS. One mobile operator at the Stakeholders' Hearings stated that it expects LTE equipment to be available for digital dividend spectrum by 2011, therefore, it would be ready to deploy a service in 2012 – when the analogue switch-off (ASO) is planned in many Member States.

- *WiMAX*

  – WiMAX was originally developed as a fixed–wireless access (FWA) technology (IEEE802.16d) and was later revised for portable and fully mobile use (IEEE 802.16e). The mobile version of WiMAX is likely to offer speeds similar to HSPA. Although WiMAX offers both TDD and FDD profiles, the most likely deployment will use TDD.20

19 FDD is more suited to operation in lower frequency bands than TDD, since it does not require a guard time between up and downlink transmissions.

20 At this stage, all the WiMAX mobile profiles use TDD.

Applicable frequencies within the 470–862MHz band

In theory, all frequencies between 470–862MHz could be used for wireless broadband. However, as discussed in detail in Section 8.7 below, it is very important in order for economies of scale to be realised, particularly for receiving devices, that spectrum is harmonised for this service. A 72MHz sub-band has been identified for wireless broadband; this is discussed in more detail in Section 6.3 below.

Alternative frequency bands and delivery platforms

The propagation characteristics of digital dividend spectrum are ideally suited to provide rural and in-building coverage for wireless broadband networks. Therefore, digital dividend spectrum could play a key role in bringing fixed, nomadic and mobile wireless broadband services to rural areas and to other households that are not served by fixed broadband technologies (e.g. DSL or fibre).

The 900MHz band, currently used for GSM, may be liberalised and used to provide wireless broadband services (using UMTS or LTE)[21]. The low frequency of this band, means that it could also be used to provide rural and in-building coverage. However, the total amount of spectrum in the 900MHz band is limited (2×35MHz), and it is still unclear how much spectrum will be used for UMTS/LTE in each Member State. Therefore, it is likely that additional low frequency spectrum will be required to meet the needs of wireless broadband. This is particularly the case if GSM networks continue to be operated and require 900MHz spectrum (including for international roaming), and if LTE networks require large bandwidths (e.g. 2×10MHz or more) to offer high-speed services.

Wireless broadband services can be provided using a variety of other frequency bands. These include the 2.1GHz band, which is currently used for UMTS, and the 2.6GHz band, which is to be awarded in most Member States in the next two years, and the 3.4GHz band. However, in the most remote areas, it may be uneconomical and less environmentally friendly to use these higher frequencies, as these areas would require several times the number of base stations to achieve similar coverage. Additionally, 470–862MHz is expected to provide better indoor coverage than spectrum in the 2.1GHz and 2.6GHz bands. These bands are likely to be used to offer high-speed services as well as increment capacity in localised, mainly urban areas.

21 Note that this is a related, but separate issue to the digital dividend.

Transmission characteristics

Wireless broadband services are mainly operated with medium-power, two-way transmission.

Typical power levels for cellular base stations are from 100W to 1.6kW (with EIRP of 20dBW to 32dBW typically, based on national restrictions that might apply on the maximum power transmitted per site).

4.1.4 Wireless broadband for public protection and disaster relief (PPDR)

Description of the services provided by this use

PPDR users include the primary 'blue light' emergency services of police, fire, ambulance, as well as security and customs & border control and the lifeboat service.

These users already have access to digital trunked PPDR systems (TETRA and TETRAPOL). However, these networks only provide voice and narrowband mobile data services. There is an increasing need for PPDR users to access broadband data applications whilst on the move (this trend in demand is discussed further in Section 4.2.4 below). Applications range from mobile access to patient records for ambulance services, through to criminal records for police services and real time video images for a number of applications associated with responding to major emergency incidents. As such, the bandwidth provided by current wireless PPDR networks may be inadequate to meet these future needs, and a wireless broadband network may be required.

Technologies used to provide this service

Existing digital trunked PPDR systems are largely based on one of two standards – TETRA and TETRAPOL – using frequencies harmonised for public safety use in the 300–400MHz band. However, as discussed above, these networks only provide voice and narrowband data services.

There is ongoing debate concerning the future technologies that might be used to do this. The TETRA standard is evolving to provide the TETRA Enhanced Data Service (TEDS), which will be an overlay to existing TETRA systems. Other potential solutions include commercially available technologies (e.g. WiMAX and LTE). Such technologies may be attractive because of economies of scale and the availability of handsets. However, in its 2008 report on public safety use of the digital dividend[22], WIK Consult concluded that dedicated networks are preferable as commercial technologies are optimised for different objectives than PPDR, namely meeting consumer experience, service and price demands. Such networks are not hardened and

22 WIK Consult (2008), "Safety first – Reinvesting the digital dividend in safeguarding citizens".

designed to cater to the stringent requirements of PPDR organisations. This issue is discussed further in Section 8.7 below.

Applicable frequencies within the 470–862MHz band

Spectrum above 350MHz and below 1GHz is most attractive for any wireless broadband network, and PPDR is no exception.

- The excellent propagation characteristics of these low frequencies means that fewer base stations are required, enabling a more cost-effective network rollout.
- Low frequencies enable wide-area and good in-building coverage and non line-of-sight operation that PPDR users require. For example, good in-building coverage is essential for fire fighting.
- Low frequencies also enable flexible cell sizes (the size of cells can always be made smaller by reducing the transmitter power of the base stations).

Alternative frequency bands and delivery platforms for these services

There are a number of potential alternative frequency bands to the digital dividend that could be used to offer wireless broadband services for PPDR users:

- **The release of NATO spectrum:** Recent work has commenced within CEPT to consider future spectrum requirements for PPDR. The focus of this work is to consider options in bands below 1GHz, since those bands provide the best characteristics to meet PPDR requirements. One option may be for CEPT to initiate further negotiation with NATO on the feasibility of releasing further spectrum for PPDR use, on a shared basis with defence. For example, frequencies around the current PPDR spectrum (380–400MHz) might be ideal to provide a future network and would also provide a simpler upgrade path from current narrowband networks. However, this may be a less attractive option than using digital dividend spectrum. Discussions with NATO to release spectrum may take some time, there may be a greater likelihood of digital dividend spectrum being available before NATO discussions are concluded.
- **872–876MHz paired with 917–921MHz:** This spectrum has been earmarked in Europe for future PPDR systems, however there are other demands upon this spectrum, such as GSM-R (private GSM systems used by railway companies).[23] Also, these bands may not provide

[23] GSM-R is an international wireless communications standard for railway communication that is based on GSM.

sufficient bandwidth for the full range of data applications that some PPDR users have identified for future use (e.g. real-time video).

- **2GHz band:** As highlighted by the satellite industry during the Stakeholders' Hearings, satellite providers will soon supply services in the 2GHz band (the S-Band) including for PPDR.
- **5GHz band:** The use of this band is currently under discussion by CEPT FM38[24], but may also be suitable for localised disaster relief. However, meeting the broadband communications needs for PPDR on a national basis (i.e. including rural areas) using a terrestrial network would not be economically viable using spectrum above 1GHz.

Transmission characteristics

Wireless broadband networks for PPDR users are mainly operated with medium-power, two-way transmission. Typical power levels for a wide area radio system are similar to those of a cellular network, e.g. from 100W to 1.6kW (20–30dBW).

4.1.5 Services ancillary to broadcasting and programme making (SAB/SAP)

Description of the services provided by this use

The SAB/SAP sector compromises a wide variety of spectrum users. These include professional users such as news-gathering organisations, commercial theatres, broadcasters and major music concerts, as well as community users such as local theatres, schools and churches. They use spectrum for a wide range of applications including wireless microphones, in-ear monitors (IEMs), talkback systems, wireless cameras, and audio and video links. SAB/SAP already uses the 470–862MHz band in all Member States. In this band, applications are primarily limited to wireless microphones, IEMs and talkback:

- Wireless microphones are used by a wide range of users such as television productions, theatre productions, outside broadcast, concerts. They can be hand-held by presenters/performers, or worn on the body.
- IEMs are low-power, wireless audio links that provide one-way communication from production staff to presenters/performers.
- Talkback is a voice communication system used to relay instructions between individuals involved in the production of a programme or event. It can provide one-way or two-way communication.

[24] A project team of the CEPT Working Group Frequency Management.

Of all of the EU regulators and spectrum management authorities, Ofcom in the UK appears to have conducted the most research into SAB/SAP use, which it refers to as programme-making and special events (PMSE). This was part of its Digital Dividend Review, and was based on the results of three detailed studies:

- a report on the use of UHF spectrum for PMSE (SAB/SAP) in the UK by Sagentia[25]
- a report on the supply and demand of spectrum for PMSE (SAB/SAP) in the UK by Quotient Associates[26]
- a report on the potential for more efficient spectrum use by wireless microphones by CSMG (although the study also covers IEMs and talkback systems).[27]

In its November 2007 consultation “Programme-making and special events: future spectrum access”, Ofcom categorised five types of SAB/SAP use:

- **Background social use**: This is typically small-scale use for social or community purposes. It is referred to as ‘background’ because it is geographically widespread and relatively uniform in volume (compared to other types of use below). Users include schools, churches and other religious institutions, local fêtes and fairs, amateur-theatre productions, and many community and local events.
- **Background commercial use**: This is similar in character to the background social use except that the users are commercial in character, and include typically small regional theatres, meeting venues and racecourses.
- **Larger-scale use within fixed sites, with multiple channels required:** These users typically have multiple pieces of equipment. They may make quite extensive use of spectrum for SAB/SAP, but the use is fixed in one location. This use is more geographically concentrated than the background use, with a focus in major urban areas, though some use is found in almost all parts of the country. Typical users in this category include larger theatres, television studios, and major exhibition sites.

25 Sagentia (December 2006), “Use of UHF spectrum for programme making & special events in the UK”.

26 Quotient Associates (December 2006), “Supply and demand of spectrum for Programme Making and Special Events in the UK”.

27 CSMG (November 2008), “Potential for more efficient spectrum use by wireless microphones”.

- **Special events:** This category includes large, one-off, short-term events. These can have spectrum needs that vary widely, from modest to very large indeed (such as major pop concerts). Examples of these events include music concerts, sporting events, and public commemorations of various kinds. Special events of this kind typically, although not exclusively, take place in densely populated urban centres.

- **Tours:** This category involves use of spectrum by a touring company operating over multiple sites. The spectrum requirements can be similar to those of special events, but the category is distinguished by the need to move from one geographical location to another. Examples of this category include tours by music bands and theatrical productions.

The above categories have different profiles of usage, and as a result the overall levels of SAB/SAP use in the 470–862MHz band varies significantly by both geography and in time. In general, use is greatest in a relatively small number of “hotspots”. These include major metropolitan areas with extensive entertainment sectors and broadcast-production activity, but also more rural locations which host major sporting occasions (e.g. golf courses, Formula 1 circuits). In this consultation Ofcom concludes that there is congestion, at certain locations and at certain times of peak demand But in most places, and for most of the time, spectrum available to SAB/SAP greatly exceeds demand.

The need for spectrum in the 470–862MHz bands can be described by the amount of spectrum each user requires, whether the user is static or tours geographical locations, and the typical technical knowledge of the user.

- **The amount of spectrum the user requires**: Background users (both social and commercial) typically need few pieces of equipment (up to a few wireless microphones and IEMs), which these can easily be accommodated into one 8MHz spectrum channel. The requirements of the other three categories can range widely, but the largest events can require more than 60 pieces of equipment, which will need several 8MHz spectrum channels.

- **Whether the user is static or tours**: Users in the tours category (by definition) move from location to location. Therefore, they require access to spectrum in each of these locations. This is important because if only interleaved spectrum is available (which varies in the frequencies available between locations), different spectrum channels may need to be used in each location (this is discussed further below). The other four categories of user typically use just one location.

- **Typical technical knowledge**: By technical knowledge we are referring to user’s ability to know which frequencies are available for SAB/SAP at each location; the tuning range of their equipment; and how to tune equipment to the appropriate spectrum channel. Such technical knowledge inevitably varies between individual users within each category, however, background users, and especially social background users, are typically less knowledgeable than commercial users.

Technologies used to provide this service

In its report, CSMG states that SAB/SAP users in the 470–862MHz band have a number of technical requirements:

- low latency (delay) is critical for many users, as most performances are live and require the audio to be synchronised with lip movement
- interference-free operation is critical for many users, especially commercial users
- reliable equipment is also needed.

As a result most equipment in the 470–862MHz band is analogue. This is because it performs well in the above criteria, and also because analogue equipment has low power consumption and is compact. However, analogue technology does have some disadvantages, especially when compared to digital equivalents (discussed further in Section 4.2.4 below):

- most equipment is inefficient in its use of spectrum, typically an 8MHz spectrum channel can only support up to only eight users
- equipment is sensitive to interference.

Applicable frequencies within the 470–862MHz band

When DTT and, potentially, broadcast mobile TV networks are deployed using MFN topology, SAB/SAP users can share spectrum with these uses on a geographical or interleaved basis, (in the ‘white spaces’). Therefore, spectrum used for SAB/SAP is scattered across the whole band.

Note that if DTT/broadcast mobile TV networks are deployed using an SFN topology, then this reduces the amount of interleaved spectrum. In theory, if all of the 470–862MHz range was used for national SFN networks (though as discussed in Section 4.2.1 below this is unlikely, at least in the short to medium term, due to coordination issues with neighbouring countries, and in order to provide regional content), then there would be no interleaved spectrum for SAB/SAP use.

In some Member States frequencies in the 470–862MHz band are currently reserved for SAB/SAP on a national (exclusive) basis, in addition to using interleaved spectrum. Seven Member States indicated that this was the case in their responses to our questionnaire, for example, Channel 63 is reserved for SAB/SAP in the Netherlands. Such national channels are of value to SAB/SAP users for two reasons.

- The tuning range of SAB/SAP equipment is finite (for a wireless microphone it is typically around 16MHz to 24MHz), therefore, different equipment may be required in different areas of a Member State, as well as in different Member States. Having at least one nationwide channel means that SAB/SAP users that travel around Member States (i.e. Tours users) do not have to duplicate equipment for use in different locations.

- New equipment can be tuned to the nationwide channel, so non-technical users do not need to know how to tune equipment to an available channel. This is particularly helpful for Background users.

As a result, at least in the UK, the vast majority of SAB/SAP use is located in the nationally available spectrum channel (Channel 69).

The importance of non-nationally available spectrum channels (i.e. using interleaved spectrum) should not be underestimated. These are used for two main reasons.

- Large events (larger-scale use within fixed sites, special events and tours) require a large number of wireless microphones/IEMs (perhaps up to 60). In any one location, up to eight wireless microphones can be fitted into an 8MHz channel, therefore large events require access to multiple spectrum channels.

- Some commercial users prefer to avoid the nationally available channels. This is because they can be heavily used and interference between wireless microphones can be a problem.

Alternative frequency bands and delivery platforms

DTT multiplexes are planned in all Member States using the 470–862MHz band to at least replace the historic analogue TV, and in many Member States further DTT multiplexes are planned. If these DTT multiplexes are deployed using MFNs or regional SFNs, SAB/SAP will be able to accommodate this with these new frequency plans.

The ability for SAB/SAP to use other frequency bands than 470–862MHz depends on the equipment, but very little current analogue equipment can operate using alternative bands. For wireless microphones/IEMs, analogue equipment is almost exclusively made for the 470–862MHz band.

Lower frequency bands would require unacceptably large antennas, while higher frequencies suffer from 'body loss'.[28] Digital wireless microphone and IEM equipment is being developed for both the 470–862MHz band and other higher frequency bands (1452–1559MHz and 1785–1800MHz). This development and other new technologies are discussed further in Section 4.2.4 below.

For talkback, equipment is available in other frequency bands, depending on frequency availability in Member States. Other frequency bands used include VHF band 1, VHF mid-band, 440–470MHz.[29]

Transmission characteristics

Wireless microphones and IEMs are typically low-power devices, of around 10mW or 20dBm. Audio links including talkback can operate at a higher power level (e.g. 5W or 7dBW).

4.1.6 Cognitive technologies

Description of the services provided by this use

As discussed in the introduction to this section, cognitive technologies are not strictly a service or use, but a family of technologies currently being developed. Cognitive technologies will be able to assess whether frequencies are in use in a particular location, and if not, transmit over those frequencies on a licence-exempt basis, thereby not causing harmful interference. As a result, these technologies may be particularly suited to using interleaved spectrum and have the potential to support a wide range of uses. This may include high-speed broadband, potentially over both short and long ranges. However, given that cognitive technologies are in their infancy, the exact uses they may enable is currently unclear.

Technologies used to provide this service

There are three approaches that cognitive technologies could use to determine whether spectrum is available: detection, geolocation databases and beacon reception. These are discussed in turn below.

- **Detection:** Devices assess whether spectrum is available by monitoring for transmissions. However, there is a problem with this approach which is often called the 'hidden terminal'. There is a risk that cognitive technologies will be less capable of detecting transmissions for a particular use than the receivers of that use (e.g. DTT). Hence, a cognitive device may behave as if there was no transmissions in a

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28 Absorption of the signal by the human body, degrading the signal quality.

29 VHF Band I is 55.75–68MHz; VHF mid band is 121–174MHz.

particular location, but in fact it is simply *unable* to detect any. it would then transmit, causing interference to the other service. Therefore cognitive devices will need to able to detect extremely low levels of transmission. In its February 2009 consultation "Digital dividend: cognitive access"[30], Ofcom (UK) recommend sensitivity parameters of -114dBm in an 8MHz channel in order to detect DTT, and -126dBm in a 200kHz channel in order to detect wireless microphones. It is unclear whether it will be financially viable to produce equipment that meets such stringent specifications.

- **Geolocation databases:** Cognitive devices could determine their location and make use of a geolocation database to determine what spectrum they can use at that location. In this case, parameters such as locational accuracy and the means and regularity of database enquiry are important. Such a database may help avoid causing interference to DTT, as the locations of DTT transmitters are well documented. However, using this approach to avoid interference to SAB/SAP use appears more problematic. Some SAB/SAP use is static over relatively long periods (e.g. in studios or theatres). These locations and the spectrum used could be entered into a database. Other SAB/SAP use is shorter term, especially electronic newsgathering (ENG), and is much more unpredictable. The latter is likely to be most problematic for a database approach, requiring very frequent updates and devices to check the database frequently. Note that in some Member States, SAB/SAP use is on a licence-exempt basis; under such conditions it will be very difficult, if not impossible, to enter the location of SAB/SAP use into a database.

- **Beacon reception:** This would involve a dedicated spectrum channel (a 'pilot channel') constantly broadcasting data to cognitive devices, enabling those devices to select an appropriate channel over which to operate. This is similar to the geolocation database approach, in that a location database of spectrum availability would be needed. It therefore suffers from many of the disadvantages of the above approach (particularly regarding knowing the location of SAB/SAP use). However, beacon reception would provide cognitive devices with real-time access to such a database. The costs of building a transmission network for the pilot channel are likely to be high, especially if the opportunity cost of access to the spectrum channel is included.

30 Ofcom (February 2009), "Digital dividend: cognitive access".

Detection appears to be simplest cognitive radio approach, but technology to deliver this is not available at present. In the short and medium term, it appears more likely that either a geolocation database or beacon reception will be more feasible. It is noted that the technical conditions in order to facilitate introduction of cognitive radio technologies are the subject of an ongoing study within CEPT and the ITU, in preparation for WRC-11.

Applicable frequencies within the 470–862MHz band

The whole 470–862MHz band, and in particular interleaved spectrum, could be made available for cognitive technologies.

Alternative frequency bands and delivery platforms for these services

Cognitive technologies are likely to be available in other spectrum bands. However, they may not be able to provide the same services as in the 470–862MHz band (due to the favourable propagation and antenna characteristics of this band).

Transmission characteristics

Cognitive technologies stakeholders claim that they could use the 470–862MHz at up to 100mW with limited interference. As discussed above, where services use spectrum on a cognitive basis, there may be other parameters required to define the system's performance in addition to power levels, such as its sensitivity level. This is to ensure that devices are able to successfully detect other transmissions within the area and avoid transmitting on that frequency.

4.1.7 Innovation reserve

Description of the services provided by this use

Like cognitive technologies, this category does not comprise a specific service that could be provided using digital dividend spectrum. Instead it relates to the principle of reserving part of the digital dividend for innovation. Such an approach could be adopted for two reasons:

- reserving spectrum specifically for experimental purposes such as trialling new technologies
- not making spectrum available until a future date.

The former is currently under consideration by ComReg in Ireland.[31] This builds on ComReg's existing wireless 'test and trial' scheme whereby an organisation or individual can apply for a licence to test or trial innovative

31 European Economics report for ComReg (October 2008), 'How Ireland can best benefit from its digital dividend: Consultancy report'.

	wireless services using any spectrum that is not currently licensed to an individual user. The aim is to encourage innovators to showcase new technologies in Ireland and later export these technologies to the rest of Europe. The second case has previously been considered by Ofcom in the UK.[32] The main aim of this approach is that given the significant uncertainties over developments in technology and future consumer demand for services, some of the digital dividend spectrum could be held back against the possibility of unexpected developments and made available at some subsequent future date.
Technologies used to provide this service	Not applicable – as indicated above, this category does not relate to a particular use or technology
Applicable frequencies within the 470–862MHz band	All frequencies across the band could be applicable.
Alternative frequency bands and delivery platforms for these services	Other frequency bands could be used to trial innovative services, however it is possible that a particular (currently unknown) innovation may value/require the special characteristics of the 470–862MHz band to prove the concept.
Transmission characteristics	Not applicable – as indicated above, this category does not relate to a particular technology and hence no specific transmission characteristic applies.

4.2 Trends in services and technologies

We discuss below forecast trends in the uses identified in Section 4.1 above (with the exception of an innovation reserve), as well as trends in the technologies that are used to provide them.

[32] Ofcom (December 2006), "Digital Dividend Review".

4.2.1 Digital terrestrial TV (DTT)

Before the development of digital TV platforms, consumers were accustomed to receiving a small number of TV programming channels (typically up to five). Since then other technologies (DTT, satellite, cable and IPTV) have been launched, offering a much wider choice of programming channels, as shown in Figure 4.1 below. Furthermore, these platforms have been successful at drawing viewers away from the analogue platform.

Member State	*Operator*	*Number of TV programming channels available*
Austria	UPC Telekabel (cable)	140
Austria	Telekom Austria (IPTV)	62
Belgium	Belgacom TV (IPTV)	80
Czech Republic	UPC (cable)	70
Czech Republic	UPC Direct (satellite)	150
Denmark	YouSee (analogue cable)	38
Denmark	YouSee (digital cable)	100
Estonia	STV (cable)	51
Estonia	Elion (IPTV)	40
Finland	Maxinetti Multi (IPTV)	40
Germany	KDG (cable)	39

Figure 4.1: Examples of TV programming channels available from cable, satellite or IPTV operators in Europe [Source: Screen Digest, Cable Europe]

It is apparent from Figure 4.1 that the trend towards greater TV programming channel choice is very advanced. There are three other significant trends that are at an earlier stage:

- consumers are demanding more non-linear services
- consumers are purchasing TVs with larger screens
- consumers are demanding more HD content.

These trends are equally demonstrated for DTT as for other TV platforms. We discuss each of these trends below.

The first trend is growth in demand for non-linear programming. Consumers want to watch content at a time they choose, known as video on-demand (VoD). An example is the rapid increase in downloads from the BBC’s iPlayer in the UK. About 800 million free-to-view TV streams and downloads were accessed by UK homes in 2007[33], and it is reported that the BBC alone accounted for 38% of free-to-view streams last year. Free-to-view TV streams and downloads are forecast to reach 2.8 billion by 2012 in the UK.[34] Also, demand for interactive services is growing. Examples

[33] Screen Digest (2007).

[34] Neon Kelly (14 February 2008), “Couch potatoes move online”.

of such services include betting or being able to pay subscription bills via your TV. These interactive services require an uplink from the TV or set-top box to the TV provider. Such uplinks are easier to provide on cable and IPTV platforms, than inherently one-way broadcast technologies such as DTT and satellite. Typically, DTT and satellite providers use consumers fixed broadband/narrowband connections to provide these uplinks.

During the Stakeholders' Hearings, broadcasters and network operators mentioned that they were testing new services such as push VoD (pre-selected video) and three-dimensional content for the DTT platform. This demonstrates their understanding of the importance of providing innovative services in order to remain competitive.

Stakeholders also mentioned that the average TV screen size being purchased each year is growing – the second trend in our list above. This is also evidenced by data from the Simavelec, which shows the average size of TV screen sold rose from 58cm in 2002, to 80cm in 2008, and is forecast to increase to 94cm in 2010.[35]

The third trend is an increased demand for HD content. Recent surveys from the BBC and the French government indicate that consumers are demanding increasing amounts of HD content. In its digital economy master plan "France Numérique 2012", the French government noted that as of July 2008, 23.8% of French households were equipped with HD capable TV sets and that analysts are expecting this figure to reach 93.2% by 2012[36] (note that there are already seven HD DTT programming channels available in France). During the Stakeholders' Hearings, one broadcaster observed that a BBC survey found that 85% of consumers in the UK had a high interest in HDTV.

Overall, all three of these major trends mean that consumers are demanding increased capacity from their TV platforms.

An additional trend to note is the increase in the number of subscribers to non-terrestrial platforms. In most Member States, cable and satellite have both gained subscribers over the last few years, as illustrated in Figure 4.2 below. In all but eight of the 26 Member States with cable offerings, the take-up as a proportion of covered household increased between 2004 and 2007. Of the 19 Member States with satellite offerings, the penetration of households increased for 11 of them between 2004 and 2007. Though note that in some instances it may be possible that increases in subscribers to one non-terrestrial platform (e.g. satellite) are at the expense of the another non-terrestrial platform (e.g. cable).

35 HD Forum (6 March 2009), "European Commission Hearings on the digital dividend".

36 France Numérique 2012 (Octobre 2008), "Plan de développement de l'économie numérique".

	Cable take up as a proportion of covered household		*Satellite penetration of TV households*	
Member State	*2004*	*2007*	*2004*	*2007*
Austria	71.33%	73.54%	38.55%	36.22%
Belgium	92.44%	85.70%	4.24%	4.11%
Bulgaria	82.43%	85.00%	No data available	No data available
Czech Republic	30.58%	34.08%	10.84%	10.18%
Denmark	82.22%	87.89%	24.17%	22.34%
Estonia	51.33%	61.53%	12.23%	14.41%
Finland	68.06%	68.78%	8.33%	8.42%
France	39.77%	43.15%	17.18%	16.84%
Germany	71.17%	67.12%	41.85%	43.40%
Hungary	72.22%	67.97%	14.85%	14.83%
Ireland	55.12%	58.50%	32.99%	34.27%
Latvia	77.26%	86.25%	No data available	No data available
Lithuania	31.66%	36.42%	No data available	No data available
Luxembourg	93.88%	89.42%	No data available	No data available
Malta	89.10%	90.42%	No data available	No data available
Netherlands	95.52%	92.40%	3.09%	5.88%
Norway	73.22%	77.81%	29.05%	31.54%
Poland	71.70%	84.92%	20.77%	20.63%
Portugal	43.97%	45.09%	11.47%	11.97%
Romania	46.45%	57.05%	2.38%	2.96%
Slovakia	81.84%	74.72%	8.55%	7.51%
Slovenia	94.64%	85.74%	No data available	No data available
Spain	14.50%	13.23%	12.98%	14.50%
Sweden	87.59%	89.11%	22.66%	22.78%
UK	26.21%	27.60%	29.09%	30.03%

Figure 4.2: *Penetration of cable and satellite TV (2004 and 2007) [Source: Screen Digest]*

In many Member States IPTV is becoming an established fourth delivery technology – subscriptions have increased rapidly, albeit from a small base, as indicated by Figure 4.3 below.

Operator	*IPTV subscribers*		*Year-on-year growth (%)*
	September 2007	*September 2008*	
Belgacom (Belgium)	249 000	443 000	78%
BT (UK)	48 000	320 000	567%
Deutsche Telekom (Germany)	50 000	257 000	414%
Orange (France)	975 000	1 533 000	57%
Telecom Italia (Italy)	40 000	218 000	445%
Telefónica (Czech Republic)	53 000	108 000	104%
TeliaSonera (Sweden)	216 000	320 000	48%

Figure 4.3: IPTV subscribers for selected operators in Europe, September 2007–September 2008 [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

Cable, satellite and IPTV are successful because they respond to the three current consumer demands given above. During the Stakeholders' Hearings, broadcasting stakeholders emphasised how important is was for DTT to be able to compete with these alternative digital platforms.

In addition to these trends in consumer demand, there are relevant technical trends, which also have a significant impact on the services that will be offered. There are currently three developments that may make DTT transmissions more spectrally efficient in the future:

- the migration to more efficient compression technologies (including MPEG-4)
- the development of DVB-T2
- the potential for more extensive use of SFNs.

We examine these three developments in turn below.

The migration to more efficient compression technologies (including MPEG-4)

MPEG is a suite of standards of which MPEG-4 is one. MPEG-4 is an advanced compression technology that enables a TV programming channel to be broadcast at a lower bit rate than earlier MPEG technologies (e.g. MPEG-2). Specifically, MPEG-4 is actually a collection of standards and is constantly under development. It is divided into 23 parts, and MPEG-4 equipment may vary in the parts that are included. One key part is part 10: H.264/AVC or Advanced Video Coding. The first version of the H.264/AVC standard of MPEG-4 was finalised in 2003. However, there are a number of number of profiles within the H.264/AVC standard, including the baseline profile

(BP), the main profile (MP), the extended profile (XP) and the high profile (HiP). The relationship between these profiles is illustrated in Figure 4.4 below:

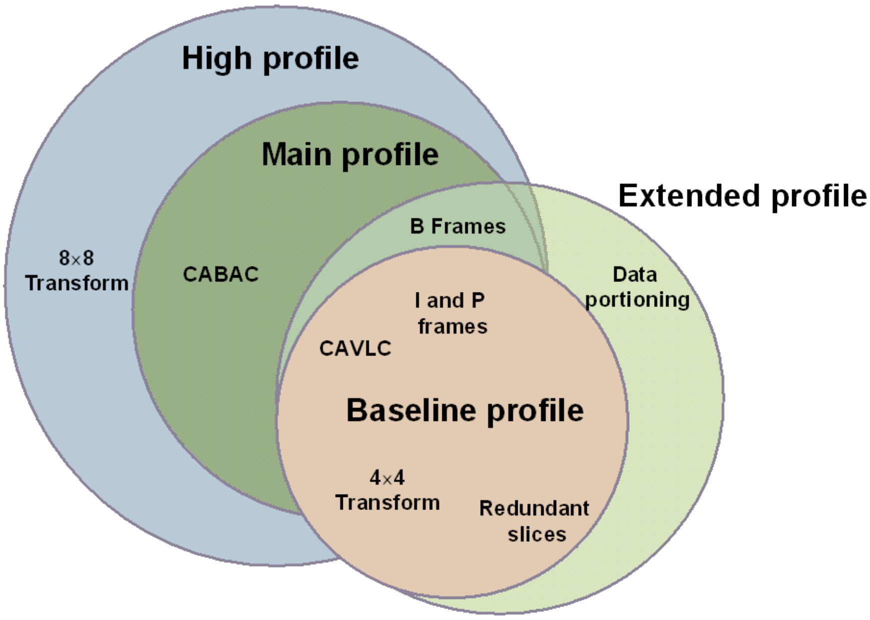

Figure 4.4 *Relationship between H.264/AVC profiles [Source: Ofcom, 2007]*

The main profile and high profile both include the context adaptive binary arithmetic coding (CABAC) scheme. It has been estimated that this gives about 10% to 15% saving in bit rate compared to the simpler context adaptive variable length coding (CAVLC). In addition, the high profile includes the use of an 8x8 transform. It has been estimated that this gives about 10% improvement in coding efficiency compared to the main profile.

The H.264/AVC high profile, which has been approved by the DVB Steering Board, enables a programming channel to be broadcast using approximately half the bit rate when compared to MPEG-2. Figure 4.5 below illustrates the approximate data rates required for SDTV and HDTV programming channels using MPEG-2 and H.264/MPEG-4 AVC (HiP). Note that the exact required data rates will depend on the SD and HD standards used. For example, the HD standard 1080p will require a higher bit rate than 1080i, since with 1080p, pixels are updated twice as often as under 1080i (which updates alternate pixel rows).

Compression technology	*SD programming channel*	*HD programming channel*
MPEG-2	3.2Mbit/s	16Mbit/s
H.264/MPEG-4 AVC (HiP)	1.6Mbit/s	8Mbit/s

Figure 4.5:Data rates required for one TV programming channel [Source: Ofcom UK[37], BBC Trust[38] Analysys Mason, DotEcon, Hogan & Hartson]

Of those Member States that have already deployed DTT, 13 have done so using MPEG-2 and six using MPEG-4 for some or all of their transmissions. Of the Member States that have not yet launched DTT, six appear to be planning to adopt MPEG-4 from the outset.

DTT compression technology	*Member States*
Currently using MPEG-2	Austria, Belgium, Cyprus*, Czech Republic, Denmark, Finland, Germany, Italy, Luxembourg, Malta, Netherlands, Spain, Sweden, UK
Currently using MPEG-4 for some or all of their transmission	Bulgaria, Estonia, France, Hungary, Ireland*, Latvia, Lithuania, Poland*, Portugal*, Romania*, Slovenia*, Slovakia*

Figure 4.6: DTT compression technologies in use across Member States in 2008 [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

*Note: * indicates countries have yet to start DTT transmission but plan to use that compression technology*

Upgrading a multiplex to deliver MPEG-4 simply involves transmitting MPEG-4 compressed TV programming channels rather than MPEG-2 compressed programming channels. Hence the incremental network cost is relatively small. Note that it is possible for TV programming channels to be transmitted using both MPEG-2 and MPEG-4 on the same multiplex. However, there may be a cost to consumers of receiving a TV programming channel that has been compressed using MPEG-4. The user's receiver (either within the TV set itself, or a separate set-top box) will need to be replaced in order to be compatible with MPEG-4. Note that receivers are typically backwards compatible, meaning in this case that MPEG-4 enabled receivers can also receive MPEG-2. Digital Tech Consulting has estimated that global shipments of set-top boxes and television receivers with hybrid MPEG-2/MPEG-4 AVC chipsets will increase from approximately 30 million in 2008 to

37 Ofcom (31 October 2007), "Review of DTT HD Capacity Issues".

38 BBC Trust (April 2008), "High Definition Services on Digital Terrestrial Television: Trust interim statement on BBC non service application".

over 100 million by 2011.[39] As highlighted by the HD Forum in its contribution to the Stakeholders' Hearings[40], in some Member States, the majority of receivers sold in the market are now MPEG-4 compatible. Figure 4.7 below provides past and projected sales figures for TV sets in France, which has a highly developed HD market. Note that as of December 2012, all new TV sets in France must be MPEG-4 enabled.[41] Even so, around half of TV sets sold in 2009 are expected not to be MPEG-4 compatible.

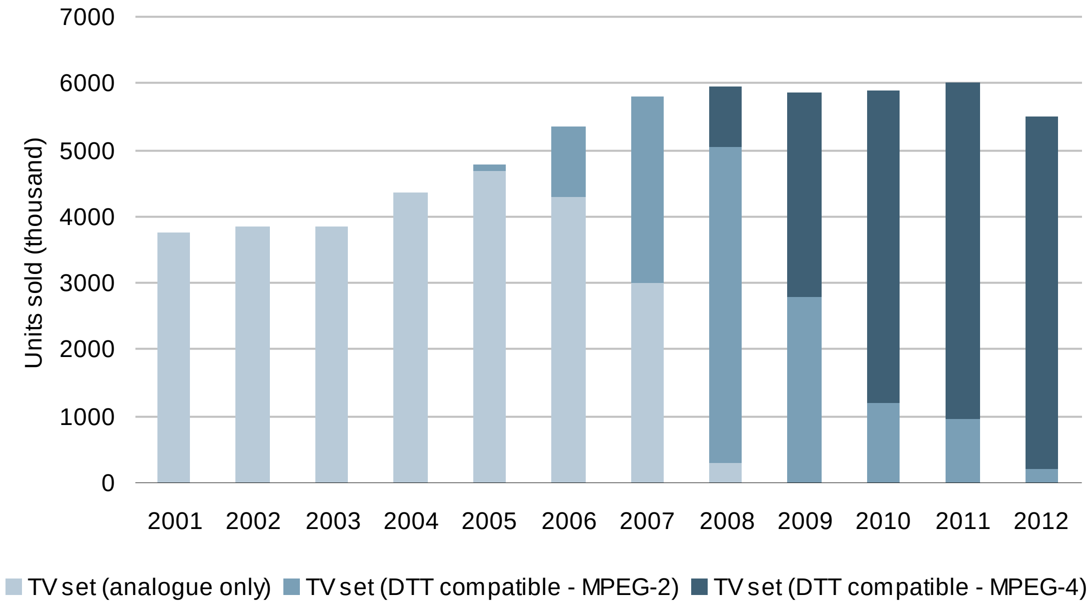

Figure 4.7: Sales and predicted sales of TV sets in France (2001–2012) [Source: HD Forum based on Gfk and Simavelec data]

Other standards under development within the MPEG group include MPEG-7 and MPEG-21. However, these are designed to complement rather than replace MPEG-4 (e.g. MPEG-7 relates to digital rights management). It is possible that further advances to MPEG-4 may be made in future, however at present this not certain.

Whilst MPEG-2 and MPEG-4 have achieved widespread adoption there are alternative compression technologies that are also still evolving, such as AAC+ in the DAB+ standard.

[39] See EETimes.com, Myra Moore (August 2009), "MPEG-4 AVC reinvigorates market for MPEG-2 codecs".

[40] See footnote 35.

[41] As set out in law n°2008-776 ("loi de modernisation de l'économie").

The development of DVB-T2

DTT is evolving to use the upcoming DVB-T2 standard, which is still under development. The DVB-T2 specification was approved by the DVB Steering Board at the end of June 2008 and from there, passed to ETSI for publication as a European standard.[42] It is likely to take until July 2009 to fully ratify the standard, EN 302 755.[43] From the Stakeholders’ Hearings we understand that DVB-T2 is likely to enable a 30% increase in the capacity of a DTT multiplex when compared to DVB-T. Therefore, a DVB-T2 multiplex will enable bit rates of up to 35Mbit/s, compared to 27Mbit/s for DVB-T.

Unlike MPEG-4, which can be used jointly with MPEG-2 on a given multiplex, DVB-T2 requires whole multiplexes to be converted from the less advanced DVB-T. This is likely to involve fairly substantial investment for DTT networks. As with MPEG-4, there will also be a cost to consumers, as users’ receivers will need to replaced to be DVB-T2 compatible.

Figure 4.8 below illustrates our estimates for the approximate number of TV programming channels that can be broadcast on a DTT multiplex using different combinations of MPEG-2/ MPEG-4 and DVB-T/DVB-T2.

	DVB-T		*DVB-T2*	
	SD channels	*HD channels*	*SD channels*	*HD channels*
MPEG-2	8	1	10	2
H.264/MPEG-4 AVC	16	3	20	4

Figure 4.8: TV programming channels per multiplex for DTT [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

The above estimates for the number of HDTV programming channels per multiplex using MPEG-4 and DVB-T2 are consistent with the views of Ofcom, which is planning an H.264/MPEG-4 AVC/DVB-T2 multiplex that will carry four HDTV programming channels. They are also consistent with the opinion of the European Broadcasting Union (EBU), which believes that using statistical multiplexing should make it possible to deliver up to four or five HDTV programming channels per multiplex.

42 See http://www.dvb.org/technology/fact_sheets/DVB-T2-Fact-Sheet.0409.pdf.

43 See http://webapp.etsi.org/workProgram/Report_Schedule.asp?WKI_ID=28396.

The potential for more extensive use of SFNs

The third relevant technological trend is the increasing use of SFNs. SFNs are one possible way to make the use of the band for DTT more efficient, and thus may either enable the implementation of more DTT multiplexes or free additional spectrum for other uses.

In a national SFN network, all transmitters in the network use the same spectrum channel, which requires Member States to be able to make the same frequency channel available everywhere in the country, including in all border areas (which depends on the ability to coordinate the same frequency with all neighbouring countries). In addition, each national SFN network must broadcast exactly the same content (programmes, advertising, data services etc.) everywhere, unless a regional SFN is used (where all the stations in a region use the same channel, but neighbouring regional SFNs use different channels). However, it should be noted that the use of regional SFNs reduce the efficiency gains from SFNs, as two regional SFNs will require two spectrum channels rather than one for a national SFN.

The importance of this latter point may vary between Member States. In many Member States, relatively little regional content is currently offered on the DTT platform, and that which is available tends to be mainly limited to regional news programmes on a few TV programming channels. Therefore, it may be possible for TV programming channels that carry regional content to be confined to a small number of multiplexes (perhaps just one or two). These multiplexes would need to use MFNs (where each multiplex uses different frequencies for each transmitter site across the Member State), or possibly regional SFNs. However, the remaining multiplexes in the Member State could be deployed using national SFNs. Further, it should be noted that there may be alternative means for consumers to receive regional TV content e.g. through the cable platform and via IPTV.

From a technical perspective, while in theory SFNs may lead to more efficient utilisation of spectrum in comparison to traditional MFNs, in practice, the operation of SFN schemes gives rise to a number of interference problems. DTT networks use Orthogonal Frequency Division Multiplexing (OFDM), in which data is carried by means of a large number of orthogonal sub-carriers closely spaced together, called symbols. As highlighted by the EBU in its contribution following the Stakeholders' Hearings[44], there are some technical issues arising from the OFDM method used in DTT that pose limits on SFN performance:

- guard interval length
- self interference
- destructive interference.

Guard interval length, which is set in the DVB-T standard, represents the permissible time period between adjacent OFDM symbols, in which the DTT receiver will 'ignore' transmission. While this feature of OFDM systems has the benefit of affording greater resilience against interference

[44] EBU's PowerPoint submission following the Stakeholders' Hearings (March 2009).

from 'delayed' signals (due to multipath effects, etc.), it has the disadvantage of setting an upper limit on the maximum possible distance between co-channel transmitters. This means that either a denser network is required, or a larger interval length, which reduces the capacity available for 'useful' transmission, thus reducing the spectrum efficiency gains from SFNs (as more multiplexes may be required compared to an MFN).

Self interference arises from a portion of signal not being received by the DTT receiver within the time width of the guard interval of an OFDM symbol, and falling in previous or subsequent OFDM symbols, producing inter-symbol interference.

With many adjacent transmitters, when sending the same signal simultaneously in an SFN, the sum of the signals from multiple distant transmitters may combine constructively or destructively. The possibility of distant transmitters combining *destructively* limits the potential for large areas to be served by individual transmitters. This creates the need to use lower power levels in order to use SFNs over large areas, to reduce the interfering distance between transmitter sites. While using lower power has the advantage of reducing interference, it means that a denser network of transmitters may be required. We understand from the Member States' workshop that high-power SFNs may be possible in transmission areas of up to 120–170km in size. Beyond this, self interference becomes problematic and lower-power, denser networks are required. Hence, regional SFNs could be deployed using high-power transmission, whilst national SFNs typically require lower-power, denser networks. We understand from the responses to the questionnaire that several Member States have deployed high-power, regional SFNs, but only Spain has deployed lower-power national SFNs.

Changing to a denser, lower-power network topology would involve four sizable costs. Two of these costs are likely to be incurred by network operators and two by consumers.

- Denser networks are typically more costly than higher-power networks, as more transmission sites are required, in particular, the cost of rural coverage will increase.
- New transmission sites would need to be identified, acquired and deployed.
- In the majority of Member States, in order to receive DTT, consumers require a roof-top aerial pointing in the direction of the nearest DTT transmitter. A denser network means that for many households the location of the nearest DTT transmitter would change. For these households, the antenna would need to be re-aligned.
- A significant number of consumers may need to upgrade to wideband antennas.

In some Member States narrowband antennas are widely deployed, however, narrowband antennas only work across a proportion of the 470–862MHz band. Typically, households in one region of a Member State have antennas that work across a certain part of the 460–862MHz band, while in other regions antennas use another part of the band. Historically, MFN networks were planned to take this into account, spectrum channels for the multiplex were chosen to be compatible with the type of antenna used in each region. However, this is not possible with a national SFN. If a national SFN is implemented using a certain spectrum channel, many households may not be able to receive the service in regions where that channel is not part of the standard antenna group. This may mean that a significant number of consumers need to upgrade to wideband antennas.

In addition to these technical issues, there is a further issue with a national SFN approach for Member States that have negotiated at GE-06 for either MFN- or regional SFN-based assignments. For these Member States, substantial re-negotiation with neighbouring countries will be required to make available the same frequency channel in all areas of the country, including border areas. Some Member States, such as Spain, have been able to implement national SFNs by re-allocating spectrum previously used for services other than analogue TV (spectrum used by the military, for instance). This spectrum does not have DTT assignments in nearby Member States. Therefore, there may be more scope for national SFNs using these channels to be implemented across the country.

There are also transition issues associated with the introduction of national SFNs. It may be difficult for a Member State to implement national SFNs during the transition from analogue to digital TV. This is because national SFNs require that the same channels are cleared across the whole country. During the transition from analogue to digital, it is likely that the required frequency channels may be used for analogue TV transmissions, which will continue in some regions until the full switchover is completed.

In summary, widespread use of SFNs has the potential to significantly increase the efficiency with which DTT uses the 470–862MHz band. With a national SFN, a single spectrum channel could be used to provide a nationwide multiplex, rather than several channels for an MFN or a regional SFN. However, there are limitations to the extent that SFNs, and particularly national SFNs, can be deployed. National SFNs cannot be used to offer regional content, and hence there may be value from a subset of multiplexes being deployed via MFNs or regional SFNs. Also SFNs will not be able to use the same spectrum channel as neighbouring countries, particularly in border areas (unless the same content is transmitted across borders).

Technical constraints mean that the full potential spectral efficiency benefits of SFNs are unlikely to be achieved in practice. This could be, for example, a result of increasing guard interval lengths which reduces the capacity of the DTT multiplex and hence the number of channels that it can carry. Other technical constraints could also lead to additional costs for both network operators (e.g. deployment of new/additional transmitter sites) and consumers (e.g. the re-alignment of roof-top antennas or purchase of new wideband antennas).

Practicalities relating to the availability of spectrum and the need for replanning of frequency assignments across the 470–862MHz band mean that national SFNs are unlikely to be widely deployed across the EU in the short to medium term.

Generally, the scope for rapidly implementing national SFNs in a Member State depends on:

- the size of the Member State – MFNs may be impractical in small Member States, such as Malta
- whether the Member State’s GE-06 plan entries have been planned on the basis of deploying national SFNs – since the conversion of MFN to SFN entries will require complex negotiation with neighbouring countries
- whether the Member State can re-allocate existing services to clear one or more single channels for use in all regions of the Member State– for example, this could be achieved in Member States where some spectrum channels have been used for military or other uses and neighbouring countries do not make use of the same channel in border areas
- the importance of regional content in the Member State – if most TV programming channels (and other content e.g. advertising or data services) can be provided on a regional basis, this facilitates the introduction of national SFNs.

While there are constraints which limit the scope for widespread deployment of national SFNs across the EU in the short term, considerable spectral efficiency benefits could be gained from deployment in the medium to long term. This could result in the release of large amounts of spectrum for other uses. The drawback of a widespread move to national SFNs is that the amount of interleaved spectrum (white space) is likely to reduce – the amount of such spectrum that remains will depend on the coordination of frequencies between Member States (particularly near border regions).

4.2.2 Broadcast mobile TV

Until around two years ago there was a great deal of interest from consumers and mobile operators in broadcast mobile TV. Since then, this interest appears to have diminished – demand for and the success of broadcast mobile TV is still not proven within Europe (or elsewhere). However, there may be some instances where broadcast mobile TV may be qualified as a success. For example, in June 2006, 3 Italia launched its DVB-H TV service (Tua) and by October 2008 had registered over 850 000 users (up from 145 000 in August 2006 and 770 000 in October 2007).[45] However, it should be noted that the service was priced lower in Italy than in other countries.

There are other instances in Europe of broadcast mobile TV being less successful. Virgin Mobile’s early DMB-based broadcast TV service in the UK, launched in 2006, ceased to operate in 2007 due to low subscriber take-up. The limited range of handsets supporting the service was a key factor. In Germany, third-party DVB-H TV licensee Mobile 3.0 also ceased providing a service.

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45 Analysys Mason (January 2009), “Italy Country report”.

This was due to the mobile operators being unwilling to distribute DVB-H-enabled handsets, citing concerns that subscribers would cut their spend on operator-provided services in order to subscribe to Mobile 3.0's TV offerings.

Outside Europe, especially in Japan and South Korea, broadcast mobile TV take-up is relatively high. The number of broadcast mobile TV subscribers in South Korea grew by almost 60% in 2008, to reach 17.25 million users.[46] However, although broadcast mobile TV is a success from a take-up point of view, we understand that operators may still be struggling to generate sufficient margins from this service, especially in South Korea where broadcast mobile TV is a free-to-view service.[47]

As highlighted in Section 4.2.1 above, there is increasing demand from consumers for non-linear rather than traditional (linear) broadcasts. This could be 'catch-up TV', where content is available for a certain period of time after its broadcast, or VoD, where content can be viewed at any time, on demand. We can expect this trend to impact broadcast mobile TV services directly. Such non-linear services may be better provided in other ways, for example over unicast mobile TV, rather than broadcast mobile TV.

4.2.3 Commercial wireless broadband

In Europe, mobile operators are experiencing a very marked increase in demand for wireless broadband. For example, data subscribers in Sweden were downloading on average between 1GB and 2GB per month[48] in 2008, a level of use similar to that for fixed broadband. Analysys Mason has forecast wireless broadband subscribers in Europe are to increase from 26.1 million in 2008 to 616.9 million in 2015[49] as illustrated by Figure 4.9 below.

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46 Broadband TV News (15 Jan 2009).

47 In South Korea T-DMB services are provided free of charge but access is limited to certain regions, whilst S-DMB services are provided on a subscription basis.

48 Analysys Mason (15 December 2008), "Mobile broadband: high take-up but high usage can lead to low profits".

49 Analysys Mason (25 July 2008), "Wireless broadband forecasts for 2008-2015: HSPA, HSPA+, EV-DO, LTE and WiMAX"

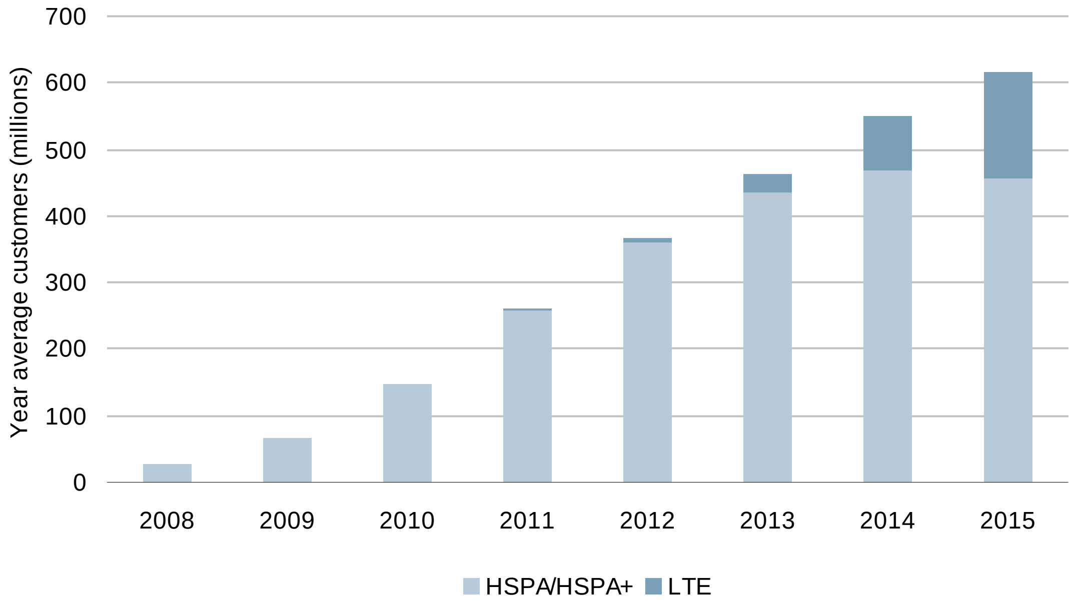

Figure 4.9: Forecast wireless broadband subscribers (2008-2015) [Source: Analysys Mason, 2008]

The reasons for this growth in demand are several. First, the price of mobile broadband has declined significantly over recent years, and now appears to be acceptable for many consumers.[50] Second, there has been significant innovation in mobile broadband devices. Devices such as Apple's iPhone and Google's G1 phone have significantly improved the user experience of mobile broadband on handheld devices, driving wireless broadband usage. Third, many European mobile operators have been upgrading their UMTS networks to HPSA, resulting in increased speeds being provided to users (theoretically up to 7.2Mbit/s). As a result, wireless broadband is becoming viewed as substitute for fixed broadband, especially for households that are not close enough to their local exchange to receive high-speed DSL services. Finally, government initiatives such as eHealth, eGovernment and eLearning are entrenching the Internet, including the mobile Internet, as a mass market information and communications platform.

The above trends are likely to continue in the future, but we can also expect more demand for wireless broadband from other areas.

- Machine-to-machine (M2M) services currently have narrow-band requirements, for instance to provide telemetry such as automated meter reading solutions for utilities; and telematics such

[50] Many European mobile operators offer capped mobile broadband packages below EUR20 per month. For example Glocalnet in Sweden proposes a download package limited to 5GB for approximately EUR17.5 per month; Vodafone in Hungary offer a 5GB download package for approximately EUR17 per month; 3 Italy offers 30 hours per month for EUR10 per month; and Telenor in Sweden proposes an unlimited mobile broadband package for approximately EUR19 per month. Source: Richard Thurston, Analysys Mason (2009), "How to succeed with mobile broadband tariffing".

as vehicle tracking. However, it is expected that in the future such services may require broadband, such as for the management of closed circuit television (CCTV) images.

- The number of gaming devices/applications that require wireless connections is increasing. This will drive up the demand for wireless broadband capacity in the coming years.

In order to cope with this increasing demand, new wireless technologies are being developed. As discussed in Section 4.1.3 above, these include LTE and WiMAX. These technologies offer higher data rates and are more spectrally efficient than previous technologies. According to the French mobile operator Bouygues Telecom[51], LTE technology will offer speeds almost ten times greater than those of UMTS/HSDPA by 2011. The increase is due to increased spectral efficiency such as higher modulation, multiple input and multiple output (MIMO) technology as well as the use of larger channel sizes (LTE profiles will use up to 2×20MHz channels). In order to use these technologies, costs will be incurred by network operators to upgrade the networks, and consumers to acquire compatible devices.

The vast majority of mobile networks both in Europe and elsewhere currently use FDD (frequency division duplex) technology. Both GSM and UMTS (including its variants such as HSPA) are FDD technologies, as is LTE.[52] These technologies require paired spectrum, one half of the pair for the downlink and the other half for the uplink. The alternative to FDD is TDD (time division duplex), which does not require paired spectrum. The most well known TDD technology is WiMAX.[53] Over the last few years WiMAX has been promoted as another, possibly superior, option to UMTS/LTE; Intel in particular, has backed this technology.

Recently, however, many mobile operators in Europe and globally have committed to LTE, hence the prospects for WiMAX are unclear, particularly in Europe. There has been interest from new WiMAX entrants in auctions (e.g. Craig Wireless acquired unpaired spectrum in the Norwegian 2.6GHz auction). However, it is not clear that new entrants will continue with their interest in such auctions given the current economic environment. Therefore, at least in the short to medium term, the principal demand appears to be for FDD technologies.

One drawback to FDD technologies is that they are somewhat inflexible about the spectrum they require. Two blocks of spectrum are required, one for the uplink and one for the downlink. Further, the duplex spacing (the frequency distance between the uplink and downlink) generally has to be fixed. This means that it can be difficult to make small increments of spectrum available for FDD technologies – as spectrum must be found for both the uplink and the downlink. TDD technologies on the other hand are intrinsically more flexible, as just one spectrum band needs to be made available. TDD technologies are currently struggling to reach the economies of scale

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51 Bouygues Telecom’s response to ARCEP’s consultation on the digital dividend.

52 Though a TDD version of UMTS is available, and a TDD version of LTE is planned.

53 There are plans for an FDD version of some WiMAX profiles.

achieved by FDD technologies. Efforts are being made to develop FDD technologies that can operate in paired spectrum with variable duplex spacing – such frequency-agile FDD technologies would be advantageous during spectrum allocation. However, at the Stakeholders’ Hearings an equipment manufacturer highlighted that such technologies are not expected to be widespread for the foreseeable future.

4.2.4 Wireless broadband for public protection and disaster relief (PPDR)

PPDR workers are increasingly being equipped with wireless laptops, handheld computers, and mobile video cameras to improve their efficiency; their ability to see what is happening at the scene; and their ability to instantly collaborate with central command, co-workers and other agencies. Video surveillance cameras and unattended sensors are becoming important tools to extend the eyes and ears of PPDR agencies (e.g. a pilot study along the USA–Mexico border uses a wireless mesh network[54]).

The need to access and share data and images is increasing, for example paramedics need to transmit medical images and or reports to colleagues ahead of their arrival at the hospital. As a result, PPDR workers need greater spectrum capacity in order to maximise available bandwidth, which might require the upgrade of their current network. The emergency services also rely on good in-building coverage in order to communicate effectively at the scenes of incidents, and so spectrum below 1GHz is particularly suited to meet their requirements.

The current generation PPDR wireless systems (TETRA and TETRAPOL) are unable to provide sufficient data rates for these needs.

Many public authorities have entered in to contracts for TETRA or TETRAPOL networks, which will expire within the next five to ten years. Under EU rules, service contracts must be re-tendered at the end of their contract term. Given the long timescales often needed by public authorities to procure major contracts of this type, work is already underway in a number of Member State to consider the future replacement of current networks and associated user requirements. These requirements are will include the need for high bandwidth wireless services to deliver the services described above.

However, the relevant public authorities (e.g. emergency services) in Member States will need to allocate scarce financial resources in order to fund the deployment of such a network. It was noted at the Stakeholders’ Hearings, that some Member States have only recently deployed narrowband systems and may be unlikely to invest in new systems in the near future.

[54] Govtech.com (2 July 2007), “Mesh Network Bolsters Border Security” .

4.2.5 Services ancillary to broadcasting and programme making (SAB/SAP)

As discussed above, In 2006, Ofcom published two reports by Sagentia[55] and Quotient[56] that considered the likely future demand of SAB/SAP in the 470–862MHz band. Both studies concluded that demand for wireless microphones (which are primarily used in the 470–862MHz band throughout Europe) will increase. The Sagentia study considers the same categories of wireless microphone users as identified in Section 4.1.5. It forecast the growth rate for each, as shown in Figure 4.10 below.

User type	*Annual forecast growth rates 2010–12*
Background – social	0%
Background – commercial	0%
Geographic peaks (larger scale use within fixed sites)	2–5%
Special event – one off (special events)	5%
Special event – touring (tours)	5%

Figure 4.10:Forecast wireless microphone demand (2010-2012) [Source: Sagentia, 2006]

It should be noted that in this table growth in ‘Background’ uses is accommodated in the Sagentia forecasts by assuming that they convert into ‘Geographic peaks’ (i.e. these uses are effectively reclassified by Sagentia). The second area of growth is special events (e.g. pop concerts), which are both increasing in number and are demanding more wireless microphones per event. Quotient Associates’ forecasts are consistent with Sagentia’s: a 20% to 30% increase (over five years) in wireless microphone demand by 2014.

From a technical perspective, there are two potential trends: the development and take-up of digital equipment, and the use of alternative technologies such as ultra wideband (UWB). These are discussed in turn below.

The majority of wireless microphones in use today are analogue. This equipment does not use spectrum particularly efficiently: only around eight microphones can be used in 8MHz of spectrum, despite each one only requiring a 200kHz channel. This is due to needing frequency separation between microphones to avoid interference. Digital wireless microphones are available and are, at least in theory, more spectrally efficient as a smaller frequency separation is required.

It its report for Ofcom, CSMG stated that improvements are needed in the efficiency of chipsets used in digital equipment to achieve the required mix of low-power operation as well as low latency and spectral efficiency. Such improvements are expected over the next five, or possibly more years. However, there is uncertainty about whether these improvements would necessarily

55 Sagentia (December 2006) “Use of UHF spectrum for programme making & special events in the UK”.

56 Quotient Associates (December 2006), “Supply and demand of spectrum for Programme Making and Special Events in the UK”.

satisfy the performance requirements of high end users, as well as significantly improve spectral efficiency. CSMG also noted that digital equipment is currently much more expensive that analogue equipment.

CSMG does note that some Japanese equipment manufacturers appear to be further developed in producing digital equipment than their European and American counterparts. Also some theatres in London's West End and on New York's Broadway make use of digital equipment, which demonstrates that such equipment can offer sufficiently high level of performance for professional users. However, the key uncertainty at present is the ability of digital equipment simultaneously to achieve the same level of performance as analogue equipment and to improve spectral efficiency.

Spectrum bands outside of 470–862MHz have also been identified for digital wireless microphones. Most notably the 1452–1559MHz and 1785–1800MHz bands have been proposed by CEPT.

- The 1452–1559MHz band has been proposed for indoor use. However, 1452–1492MHz has been awarded for alternative uses in several Member States. Availability is further limited by the usage of just under half of the band by satellite services.

- The 1785–1800MHz band is allocated to fixed and mobile on a primary basis throughout Europe, however, this is not binding for Member States. Even so, few digital wireless microphones have been developed to operate in this band.

In its report, CSMG identifies that other technologies could be used in frequencies above 3GHz to provide equivalent functionality to wireless microphones, IEMs and talkback. In particular UWB technologies may be used. UWB has been approved primarily for use in mass-market consumer electronics applications in the EU.[57] However, this technology is likely to be limited to short-range SAB/SAP applications, which permit line-of-sight between the transmitter and the receiver.

However, CSMG conclude that the 470–862MHz band will remain critical to many SAB/SAP users through to the medium term (to 2018), and that over time frame analogue technology will remain the preferred choice to many users because of its cost advantages and long replacement cycles of equipment. A similar view was provided by APWPT in its contributions to the Stakeholders' Hearings.[58] CSMG notes that the most useful spectrum for SAB/SAP above the 470–862MHz band, is just above these bands (i.e. the 1452–1559MHz and 1785–1800MHz bands), and that some users may start to use these bands in the short term (before 2012).

57 Commission Decision 2007/131/EC of 21 January 2007 on allowing the use of radio spectrum for equipment using ultra-wideband technology in a harmonised manner in the Community.

58 APWPT's submission following the Stakeholders' Hearings (March 2009).

4.2.6 Cognitive technologies

The RSPG predicts that there will be greater use of cognitive technologies in many frequency bands.[59] A major advantage to using cognitive technologies is that it encourages innovation by giving users rapid access to spectrum with minimal barriers to entry. Cognitive technologies also provide a mechanism for addressing niche markets that might go unserved if potential users were obliged to navigate complex licensing processes. Consequently, the use of unlicensed spectrum could increase rapidly. Currently, the cognitive applications that are most commonly forecast to be used worldwide are short-range systems such as wireless local area networks and radio frequency identification systems. Other applications include those operating over frequencies below 1GHz, such as wireless alarms, hearing aids and medical applications.

Outside the EU, the Federal Communications Commission (FCC) in the USA in November 2008 accepted the recommendations of a report to allow the introduction of cognitive devices using white space spectrum interleaved with DTT.[60] Based on this decision, manufacturers can offer transmitting devices that can use interleaved spectrum without the user requiring a formal licence. Companies such as Microsoft, Google and Intel have been strong advocates of the unlicensed use of interleaved spectrum in the USA. Together with manufacturers such as Motorola and Hewlett Packard, they have called for the introduction of new devices that will allow users to have ubiquitous wireless access to the Internet. American broadcasters fear that devices using interleaved spectrum will interfere with existing TV services and wireless microphones, and have therefore argued that services using interleaved spectrum should be operated on a licensed basis only.

As part of this decision, cognitive devices may be required to use both spectrum detection and geolocation. Mobile devices will be allowed to transmit at up to 100mW (50mW in channels adjacent to DTT) if they can detect DTT signals and wireless microphones as low as -114dBm, locate their position to within 50 metres, and consult a database of information about available spectrum in that location. Devices that use detection alone are allowed, but their output power is restricted to 50mW. The FCC has set aside two channels in every location across the USA for exclusive SAB/SAP use alone, therefore not allowing use by cognitive devices.

Studies continue within the ITU-R in preparation for WRC-11 agenda item 1.19 (regarding regulatory measures to enable the introduction of software-defined radio and cognitive radio systems). European regulators are contributing via CEPT, including a study partly funded by the Commission.[61] These studies will be important in order to define regulatory conditions within which cognitive radio can operate on a worldwide basis, including in Europe.

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59 RSPG (May 2007), Response to a request by the Commission for an opinion on aspects of a European approach to CUS.

60 See: http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-08-260A1.doc.

61 EC FP6 E^{2}R (1 March 2004).

5 How is the 470–862MHz band currently managed?

In this section we discuss the role of Member States and the EU in the allocation and assignment of spectrum and provide an overview of the previous management of the 470–862MHz band. We discuss recent efforts to coordinate this band across the EU, before outlining its likely future management.

5.1 Responsibility for managing spectrum

In order to explain the current management of the 470–862MHz band, we first outline the roles of relevant international, European and national bodies. We then discuss who is responsible for the allocation and assignment of spectrum.

5.1.1 The roles of international, European and national bodies

Spectrum management authorities (SMAs) in Europe manage spectrum within the international framework set by the ITU in accordance with EU policy[62]. For most Member States the SMA is their national regulatory authority. The international framework takes into account decisions of the Radio Spectrum Committee (RSC) and strategic advice from the RSPG. Allocations for radio spectrum are defined by reference to the ITU International Table of Allocations, which is reflected in a European Common Allocation Table and in national frequency plans.

The Conference of European Postal and Telecommunications Administrations (CEPT) plays an important role both in maintaining the European Common Allocation Table and coordinating the European views expressed in ITU World Radiocommunication Conferences (WRCs). The CEPT also prepares necessary technical studies relating to frequency allocations in Europe. These include assessments of the compatibility of different uses, leading to non-binding decisions on spectrum allocations and recommendations to facilitate the coordination of systems operating in the same or neighbouring frequency bands in different countries. For interference management purposes, Member States work closely with their neighbours in order to manage interference issues, using the procedures of the ITU and CEPT.

62 Authority over spectrum management in some Member States is shared. For example, in France the agency responsible for spectrum management, the ANFR, is separate from the national regulatory authority, ART. In some Member States with a federal or regional structure, such as Belgium, management oversight (especially of broadcast spectrum) may be shared between the national regulatory authority and other agencies.

5.1.2 Responsibility for the allocation of spectrum

Allocation and assignment of radio frequencies are defined in the ITU Radio Regulations. *Allocation* is the entry of a given frequency band into the Table of Frequency Allocations for a purpose under specified conditions (RR1.16). For our purposes, the important element of allocation is a legal determination that a frequency band can be used for a specific service. *Assignment* is the authorisation by an administration (a country) for a user to use a frequency under specified conditions (RR1.18). This act would generally correspond to granting a right of use under Community terms.

A limited number of decisions require the allocation of spectrum for a particular purpose, such as decisions in which the Community has been involved in setting harmonised bands for specific technologies (e.g. GSM900, DCS1800, TFTS). In addition, “technical implementing measures” to harmonise the conditions for the availability and efficient use of spectrum can be adopted through the Radio Spectrum Decision.[63] This decision establishes a committee made up of Member State representatives to assist the Commission to develop such measures, such as those adopted on S-band MSS and WAPECS.[64] Under the committee procedures, a weighted majority is required to adopt such a measure, which takes the form of a Commission decision. The decision enables the Commission to issue mandates to CEPT for the development of these measures, especially for the analysis of technical issues and compatibility assessments. However, most spectrum allocation decisions are taken at a national level by SMAs, often reflecting technical assessments made by the ITU or CEPT.

5.1.3 Responsibility for the assignment of spectrum

The international structure for allocations does not affect the assignment of spectrum rights of use within the allocations, which is for the Member State to decide. Member States are therefore responsible for assigning frequencies to specific users, unless they have decided to permit unlicensed use of the frequency, in which case an assignment is not needed. An assignment has two components: a limit on the number of rights of use to be granted for frequencies, if necessary, and determinations of which user(s) will be granted the rights of use.

Member States can assign rights of use under the generic requirement of the Framework Directive Article 9(2) that they “promote the harmonisation of use of radio frequencies across the Community”. Authorisation Directive Articles 5 and 7 establish steps a Member State must take

[63] Decision No 676/2002/EC of the European Parliament and of the Council of 7 March 2002 on a regulatory framework for radio spectrum policy, OJ L 108/1, 24 April 2002 (“Radio Spectrum Decision”). This decision is part of the electronic communications regulatory framework, which includes the Framework Directive 2002/21/EC, OJ L 108/33, 24 April 2002, and the Authorisation Directive 2002/20/EC, OJ L 108/21, 24 April 2002.

[64] Wireless Access Policy for Electronic Communication Services (WAPECS) is the name given to initiatives to apply service- and technology-neutral licensing conditions to different spectrum bands used for wireless broadband services, based on the concept of Block Edge Masks (BEM) rather than technology-specific usage conditions.

before limiting the number of rights of use. Rights of use could be limited for any frequency band where there is the potential for harmful interference without such limits. Where there is a need for limits, Member States must grant rights of use based on selection criteria that are "objective, transparent, non-discriminatory and proportionate."[65]

An important constraint on these provisions of the directives is that each is "without prejudice" to content and audiovisual media policy. Thus, Authorisation Directive Article 5(2) states that the substantive conditions for granting rights of use are "[w]ithout prejudice to specific criteria and procedures adopted by Member States to grant rights of use of radio frequencies to providers of radio or TV broadcast content services with a view to pursuing general interest objectives in conformity with Community law …"[66]

Broadcasting falls within the category of "services of a general interest".[67] Thus, the additional competence of Member States to pursue general interest objectives gives them additional authority to allocate the digital dividend for broadcasting purposes if they so choose. Member States have an "essential role" and "wide discretion" with respect to services of a general interest. "It is above all the responsibility of public authorities at the appropriate level, regional or national level and in full transparency to define the missions of services of general interest and the way they will be fulfilled."[68] The role of the Commission with respect to the public service role defined by the Member States is limited to checking for manifest error.[69]

An additional consideration in broadcasting is the role of public service broadcasters, who claim a special role in cultural exchange. It is apparent that Member States have considerable scope to determine how many broadcasters (especially public service broadcasters), are needed in their country. That is significant in determining the amount of spectrum that should be allocated to the broadcasting sector from the digital dividend.

The electronic communications regulatory framework is under review and important amendments that affect the harmonisation of spectrum are under consideration. These amendments may depend on Member State implementation that could last for a year or more. Thus, it is likely that many of

65 Authorisation Directive, Article 7(3). The Electronic Communications Competition Directive echoes this last provision, by stating in Article 4(2) that the assignment of radio frequencies shall be based on the same list of criteria. Commission Directive 2002/77/EC of 16 September 2002 on competition in the markets for electronic communications networks and services, OJ L 249/21, 17 September 2002.

66 This provision in the Authorisation Directive is repeated in Electronic Communications Competition Directive Article 4. See also Framework Directive Article 1(3), which states that "[t]his Directive as well as the Specific Directives are without prejudice to measures taken at Community or national level, in compliance with Community law, to pursue general interest objectives, in particular relating to content regulation and audio-visual policy".

67 See Article 14 EU; Protocols No. 26 on Services of General Interest and No. 29 on the system of public broadcasting in the Member States; "Services of general interest … a new European Commitment," COM(2007) 725 (21 November 2007), "White Paper on services of general interest," COM(2004) 374 (12 June 2004.)

68 COM(2000) 580, at page 3 (20 September 2000) "Services of General Interest in Europe".

69 Communication from the Commission on the application of State aid rules to public service broadcasting, 2001/C 320/04, OJ C 320, 15 November 2001, at page 9, paragraph 36.

the most important decisions on managing the digital dividend will be taken in light of the *current* framework, under which spectrum management is ultimately the responsibility of the Member States.

5.2 Previous management of the 470–862MHz band: Stockholm, GE-06 and WRC-07

Below we introduce the Stockholm and GE-06 Agreements, then discuss the relevant outcomes of WRC-07. We also discuss the implications of these agreements on the use of the digital dividend.

5.2.1 The GE-06 and Stockholm agreements

In addition to the general ITU Table of Allocations and European Common Allocation Table mentioned above, broadcasting frequencies are planned at an ITU Regional level to avoid the potential for interference from high-power signals across national borders. The ITU Regional Radiocommunication Conference met twice (2004 and 2006) to develop the plan for terrestrial digital broadcasting frequencies in Europe and other countries in ITU Region 1.[70] The results are known as the Geneva 2006 Agreement (GE-06 or RRC-06). This agreement replaces the results of the previous planning conference, which was adopted in Stockholm in 1961 and resulted in a plan for analogue channels. As well as providing the basis for planning DTT, the new plan also allows for the protection of other primary services operating in the 470–862MHz band (such as radio astronomy in Channel 38).

In preparation for GE-06, the Commission noted that “planning of radio and TV broadcasting frequencies has traditionally been coordinated at international level because of the high potential for long distance interference created by the transmission of broadcasting signals from high-power towers.”[71] In September 2005 the Commission communicated its spectrum priorities for the conference, identifying high-level goals for the Member States to achieve at the conference. One goal was that the regulatory treatment for the digital dividend complies with the EU framework for electronic communications services. The Commission participated very actively in preparations for the conference, although not as a voting administration, which is reserved for Member States.

Under the GE-06 plan, individual countries are granted the right to assign specific frequencies for DTT, at particular locations and at particular power levels (where these are known). These are known as ‘assignments’. If detailed DTT transmitter location/power plans are not available, Member States are instead granted ‘allotments’ within the GE-06 plan, which they can convert to assignments once details are confirmed. All of the technical features are listed in a document called the “Digital Plan”, which forms part of the GE-06 Agreement.

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70 See COM(2005) 461 (29 September 2005), the Commission communication issued in preparation for the RRC second session. ITU Region 1 covers Europe and Africa, plus some countries to the east of Europe, including about 120 nations in total.

71 COM(2005) 461 at page 3.

Although GE-06 focused on broadcasting services, it does not preclude a Member State from using its plan entries for other uses, providing that those alternative uses comply with the technical conditions set out within the plan. However, an important implication of the GE-06 plan is that alternative uses are not protected from harmful interference from DTT transmissions in other countries. For example, the plan provides no process for notifying (i.e. filing with the ITU) mobile uplink transmissions for the purposes of protection. In addition, since the plan has been produced for the coordination of DTT networks, it is based upon typical DTT planning parameters (propagation models, receiver heights, field strength trigger values), which are not representative of other prospective uses.

Frequency coordination methods for other potential uses of the digital dividend are therefore not covered by the GE-06 plan and hence will require an alternative methodology, which is being developed within CEPT and the ITU.

5.2.2 WRC-07

The ITU World Radiocommunication Conference in 2007 (WRC-07) adopted changes to the Table of Frequency Allocations that affect the 470–862MHz band, by identifying the 790–862MHz sub-band as one of the main bands for the deployment of advanced mobile technologies (such as wireless broadband). The Commission again prepared very actively for WRC-07. Beforehand, the Commission asked the RSPG to provide it with advice on the policy priorities and objectives to be pursued by the EU. Jointly with CEPT, the Commission sponsored workshops at the conference to discuss European policy objectives and then issued a communication outlining those objectives in July 2007.[72] One of those objectives related to the optimal use of the digital dividend, which the Commission stated would require the removal of regulatory barriers to the use of services in the 470–862MHz band. This included upgrading the status of mobile services for protection in the ITU Radio Regulations to the same status as broadcasting services, i.e. making them co-primary with broadcasting, which was accomplished through the changes to the sub-band. The Council's resolution in support of the Commission's communication broadly supported continuing to examine the regulatory status of the mobile services in the band.[73]

5.2.3 Implications of these agreements

Before changes were made by the GE-06 Agreement, the international frequency plan for broadcasting in Europe was the Regional Agreement made in Stockholm in 1961; African countries adopted their plan in 1989. Both these agreements were replaced by GE-06. Even though

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72 "Commission identifies Europe's radio spectrum needs in forthcoming global negotiations," IP/07/987, 2 July 2007.

73 COM(2007) 371, 2 July 2007, at pages 6-7, Council Conclusions of 1–2 October 2007.

they contained provisions for updating, and had certain flexibility, changes in technology and other developments led to a necessary revision.[74] The current pace of technological change indicates that further changes will be needed sooner than otherwise anticipated.

Both the GE-06 plan and WRC-07 results establish international treaty obligations. The binding level of these obligations, however, can easily be over-stated. The functioning of the ITU Radio Regulations resulting from WRC-07 is based more on international comity and the pragmatic need to negotiate with neighbouring countries, rather than legal precision. For instance, Member States have made a practice of signing all ITU conference results with a reservation stating they will apply the results only so far as the results comply with the EC Treaty. All Member States included the following in the GE-06 results:

> "The delegations of the Member States of the European Union and of the Countries which have signed an Accession Treaty with the European Union declare that the Member States of the European Union as well as the Countries which have signed the Accession Treaty with the European Union will apply the provisions of the Final Acts of the Regional Radiocommunication Conference 2006 (RRC-06) as adopted by this conference in accordance with their obligations under the EC Treaty."[75]

It is worth noting that the results of the GE-06 and WRC-07 are not treaty obligations until ratified which, depending on national law, may require subsequent actions by a Member State's government.[76] Not all Member States have been prompt in submitting final official actions to make ITU conference results legally binding. At least one Member State did not submit official ratifications to the Stockholm 1961 Agreement until 2004.

The Member States, joined by several other European countries, have also added a reservation referencing any other previous reservations they made in previous conferences, stating:

> "[T]he delegations of the above-mentioned countries formally declare that they maintain the declarations and reservations made by their countries when signing the Final Acts of previous treaty-making conferences of the Union as if they were made in full at this Regional Radiocommunication Conference."[77]

Because the GE-06 results do not pre-date the EC Treaty, there is no need to reflect on whether EC Treaty Article 307 requires Member States to eliminate any incompatibility – Member States

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74 European countries agreed to technical criteria for introduction of digital television in 1997, through a multilateral coordination agreement called the Chester Agreement 1997. This agreement did not, however, modify the plan allotments for broadcasting, and thus was insufficient to update the Stockholm 1961 agreement.

75 Reservation 8, Declarations and Reservations, Conference Plenary Document 174, Rev. 1, 15 June 2006, submitted by all 27 Member States.

76 See Generally ITU Constitution Article 54.

77 Reservation 44.

cannot bind themselves to later incompatible agreements. Therefore, if the Community defined an overarching EU policy reflected in a different allocation scheme, in theory the Member States could rely on these reservations to renounce the GE-06 plan.

However, to add more caveats, Member States also included a reservation joined by 26 other European and African countries on the substance of the plan, declaring:

> "[T]heir administrations may use their digital Plan entries for broadcasting or other terrestrial applications with characteristics that may be different from those appearing in the Plan within the envelope of their digital Plan entries under the provisions of the GE06 Agreement and the Radio Regulations, and … their administrations agree that any such use will be afforded protection to the levels defined by the interfering field strengths as arising from their digital Plan entries, taking into account any relevant bilateral agreements."[78]

Through this reservation, Member States have insisted on the right to allocate frequencies for services different from those in the GE-06 plan.[79] If an ITU Member State makes a reservation concerning provisions of a revised radio regulation, including the GE-06 results, then no other Member State is obliged to observe that provision in relation to the Member State that has made the reservation. This condition normally is reflected in the preamble to ITU agreements, as it was with GE-06 and WRC-07.

Further to the reservations made by Member States, under ITU Radio Regulation 4.4 countries always retain the option to assign frequencies in derogation of the international rules on the condition that the station shall not cause harmful interference to (or claim protection from harmful interference caused by) a station operating in accordance with the rules. The Community has expressly accepted this provision as grounds for frequency allocations otherwise inconsistent with the Radio Regulations.[80] In practice, it permits Member States to agree amongst themselves on new harmonised frequency allocations and assignments, as long as the results do not increase harmful interference to neighbouring countries.

In summary, the GE-06 results are indicative and set technical rules that all Member States will try to implement. It would be difficult to consider these rules as binding legal obligations, however,

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78 Reservation 42.

79 One Member State took a broader reservation to the GE-06 results. Italian Reservation 45 provides that in Italy: *"because of the geographical particularities of the country, it has been necessary to set up broadcasting networks which consist of an (sic) high number of stations to cover the entire territory with intense use of the spectrum and changes in the characteristics of broadcasting stations already in use would be a matter of serious technical difficulty".* Notably, Italy has been locked for some years in a dispute with a neighbouring Member State over interference from Italian broadcasting stations, which ITU mechanisms have failed to resolve. Other reservations were submitted by Cyprus, which says it will not protect Turkish stations (Reservation 10), which Turkey reciprocated in Reservation 19.

80 See Recital 8 to Commission Decision of 17 January 2005 on the harmonisation of the 24GHz range radio spectrum band, OJ L 21/15, 25 January 2005.

given the uncertainties of their binding nature and enforcement. Because the Member States all operate under the general structure of the ITU Radio Regulations in this and in many other radiocommunication fields, it is unlikely that either the Community or (most) Member States would be willing to operate outside the bounds of the GE-06 Agreement, but those results give substantial room for flexibility.

5.3 EU efforts to coordinate use of the 470–862MHz band: recent activities

The Commission has expressed a strong and continuing interest in harmonising actions regarding the digital dividend. Both the Council and European Parliament have called upon Member States to cooperate in achieving this harmonisation. In its Resolution of 24 September 2008, the European Parliament urged Member States to release their digital dividend “as quickly as possible” while emphasising that “active cooperation between Member States to overcome obstacles existing at national level for the efficient (re)allocation of the digital dividend is required.”

The Parliament also explicitly supported “a coordinated approach at Community level.”[81] The Council, at its meeting on 12–13 June 2008, invited Member States to define elements for “close cooperation” and to work together to facilitate cross-border spectrum coordination, while also inviting the Commission to support and assist the Member States “in the process of achieving close cooperation”.[82] The Council recognised that the GE-06 Agreement and WRC-07 changes “provide the basis of the international framework within which spectrum coordination of the digital dividend can be undertaken”.[83] The European Parliament also noted that any coordinated approach at the EU level would be based on the outcomes of the two international agreements reached through the ITU.[84]

5.3.1 Application clusters

In an early effort to develop an EU approach towards the digital dividend, in November 2007 the Commission released a communication on developing a common approach.[85] The Commission noted that “the UHF bands affected by the digital dividend are currently scattered in narrow segments … reflecting the spectrum plan of the Geneva 2006 agreement.”[86] It identified a “major

81 European Parliament Resolution, Resolves 14 and 48.

82 Conclusions of the Transport, Telecommunications and Energy Council, 12–13 June 2008, Invites 6 (a) and (b), and 7 (d).

83 Council Conclusions, 12-13 June 2008, Recognises 4 (e).

84 Resolves 48.

85 COM(2007) 700 (13 November 2007), “Reaping the full benefits of the digital dividend in Europe: A common approach to the use of the spectrum released by the digital switchover”.

86 See at page 6.

hurdle” of coordinating spectrum bands under the plan in a way that makes the spectrum more usable and consistent across borders. This goal can be achieved, according to the Commission, under the GE-06 plan “compatible with international agreements with neighbouring countries and with minor adaptations to meet internal EU requirements”.

The approach that the Commission proposed was to adopt a harmonised set of ‘clusters’ of sub-bands within the entire 470–862MHz band. For illustrative purposes, the Commission suggested the band would be dedicated to services divided into three categories (‘clusters’):

- spectrum under exclusive national management for the continuation of existing broadcasting services and possibly other national services (shown on the left of Figure 5.1 below)
- spectrum coordinated at the EU level for one-way, low- to medium-power services, e.g. mobile TV (shown on the centre right of the Figure)
- spectrum coordinated at the EU level for two-way, low-power services e.g. wireless broadband access (shown on the right of the Figure).

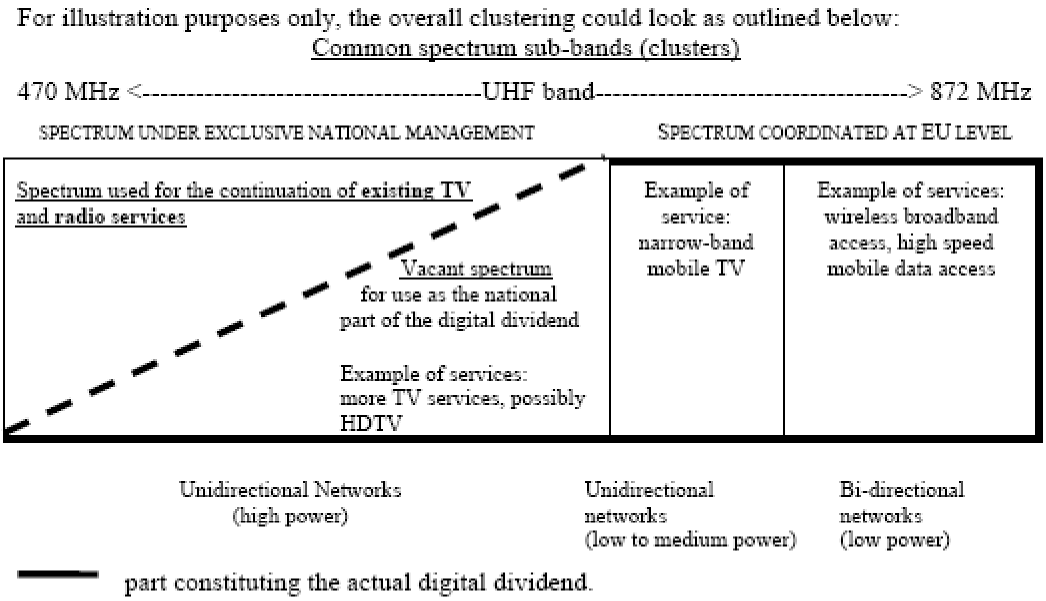

Figure 5.1: Potential clustering of sub-bands [Source: European Commission, 2007]

In response, the Council recognised the potential benefits of a coordinated EU approach. The Council invited Member States to work together, facilitate cross-border spectrum coordination based on the results of the ITU conferences, and use the 470–862MHz band in accordance with the provisions adopted at the ITU level. The Council invited the Commission to initiate necessary studies and consultations on the coordinated use of the spectrum. The Council emphasised the need for a wide and open investigation; it called for the Commission to report back by December 2008 on the results of the process and on any further steps required.[87] The Parliament urged the Commission to undertake appropriate studies on the benefits of a harmonised approach, and after consultation with the RSPG and CEPT, to submit a proposal for better coordination measures.[88]

5.3.2 Mandates to CEPT

In order to prepare the appropriate studies and consultations, the RSC issued two mandates to CEPT to examine the technical considerations relating to the digital dividend in Europe. The first mandate was issued in January 2007, and was on technical considerations regarding harmonisation options for the digital dividend; it resulted in three CEPT reports prepared by European Communications Committee Task Group 4 (ECC TG4). The second mandate, intended as a follow-up to the first, was issued in April 2008. ECC TG4 was in the process of completing deliverables to respond to this second mandate at the time of producing this report. The results of CEPT’s work in response to the two Commission mandates are further described in Section 7.2 of this report.

More recently, ECC TG4 has started work on a number of new reports, to be completed during 2009, which include processes for coordinating mobile networks in one country with DTT in another. The reports also include the rearrangement activities necessary to release a sub-band from 790–862MHz for mobile use (consistent with the WRC-07 outcome).

Following the WRC-07 decision to allocate the 790–862MHz sub-band to mobile services on a co-primary basis with broadcasting, i.e., giving both equal rights to the band, CEPT has considered possible harmonised band plans for the deployment of wireless broadband services within this sub-band.

The ECC established a project team, PT1, which is currently studying how to divide the sub-band into channels. At the time of writing this study by PT1 was in progress, however, a draft report had been published which proposes an FDD band plan as the preferred option. This is based on 5MHz blocks, and that the duplex direction should be the reverse of the standard mobile operation (i.e. the uplink will be in the upper portion of the sub-band). A duplex gap of 11MHz is suggested, with a 1MHz guard band between 790MHz and 791MHz. An optional TDD plan is also developed within the report, based on 13 blocks of 5MHz.

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87 Council Conclusions of 12–13 June 2008.

88 European Parliament resolution 2008/2099 (INI) (24 September 2008) 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.

For TDD, a 7MHz guard band is proposed to protect DTT from interference from the TDD uplink. This guard band is not required in the FDD band plan, because the band plan places the FDD uplink at the top of the band, therefore providing sufficient frequency separation from the nearest DTT channel to avoid interference.

The proposed preferred FDD band plan, along with the optional TDD band plan, are illustrated in Figure 5.2 below.

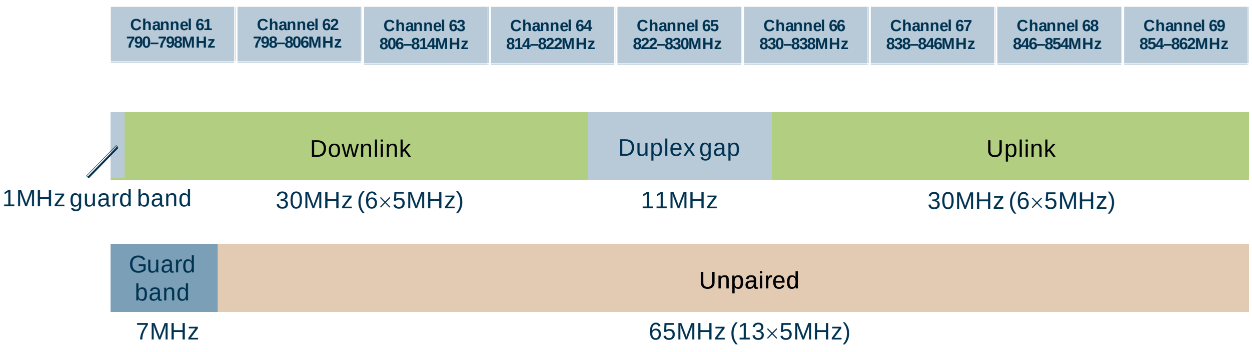

Figure 5.2: Recommended channel arrangements for the 790–862MHz sub-band [Source: ECC PT1]

5.4 Future management of the 470–862MHz band

WRC-07 identified a number of frequency bands for mobile telecommunications, including spectrum within the 470–862MHz band:

- 790–862MHz in Region 1 (including Europe, Middle East, Africa and Russia)
- 698–862MHz in Region 2 (Americas)
- 790–960MHz in Region 3 (Asia).

Resolution 749 of WRC-07 also requests studies on the use of 790–862MHz by mobile applications and other services to be conducted for consideration at WRC-11 (recently rescheduled to 2012). WRC-11 Agenda item 1.17 will consider the results of these studies.[89] This agenda item is therefore highly relevant to the Commission in relation to exploiting use of the digital dividend,

89 WRC-2011 Agenda Item 1.17, “to consider results of sharing studies between the mobile service and other services in the band 790–862MHz in Regions 1 and 3, in accordance with Resolution [COM4/13] (WRC-07), to ensure the adequate protection of services to which this frequency band is allocated, and take appropriate action.”

given that this agenda item relates to the proposed sub-band for wireless broadband use, and the frequency arrangements within which systems might be deployed in a harmonised way.[90]

Joint Task Group 5-6 has been created within the ITU-R to conduct compatibility studies regarding 790–862MHz in preparation for WRC-11. In addition, Working Party 5D of the ITU-R has been asked to develop frequency arrangements for mobile telecommunications use of the 790–862MHz sub-band. European inputs to these ITU-R working groups are being coordinated through the relevant working groups of the CEPT ECC.

CEPT preparations for WRC-11 will be carried out by the Conference Preparatory Group (CPG), which will receive input from ECC TG4 (for compatibility studies relating to the 790–862MHz sub-band) and ECC PT1 (concerning draft band plans).

We understand that the above CPG discussions (for WRC-11 agenda item 1.17, and the Joint Task Group 5-6) are ongoing. Recently these have considered what appropriate parameters should be applied when undertaking coordination procedures to protect wireless broadband systems using 470–862MHz, under the GE-06 Agreement.[91] The WRC-11 agenda item will also consider the protection to aeronautical radio services, which use 645–862MHz in some CEPT countries.

We also note that the introduction of software-defined radio and cognitive radio will be discussed at WRC-11 under agenda item 1.19. Various technical options are currently under consideration, including use of geo-database systems and a cognitive pilot channel. The outcome of this agenda item is likely to have a strong bearing on the future development of cognitive technologies.

While WRCs take place every few years, Regional Radiocommunication Conferences (RRCs), such as GE-06, are only convened when required. There is currently no plan to hold any RRC relating to the 470–862MHz band.

5.5 Summary

Member States are generally responsible for decisions on radio spectrum allocations and assignments. They make those decisions within the electronic communications regulatory framework. For interference management reasons, Member States also work closely with their neighbours through the ITU and CEPT. In particular, the GE-06 Agreement sets the parameters for how the 470–862MHz band will be used. Although it is an international treaty, the GE-06 Agreement also provides much latitude to ITU Member States. Nevertheless, due to practical (interference mitigation) reasons Member States generally are unwilling to operate completely outside of the bounds of the ITU Radio Regulations and GE-06.

[90] WRC-2011 Agenda Item 1.17, "to consider results of sharing studies between the mobile service and other services in the band 790–862MHz in Regions 1 and 3, in accordance with Resolution [COM4/13] (WRC-07), to ensure the adequate protection of services to which this frequency band is allocated, and take appropriate action."

[91] For example, CPG PTD (09)016, Agenda item 1.17, consideration of the mobile service in the GE-06 Agreement.

Member States can introduce other services in the 470–862MHz band while staying within the GE-06 plan. However, other services cannot cause more interference to neighbours at any frequency than the corresponding DTT transmission would have caused. In addition, they will not receive protection from interference from DTT transmissions in neighbouring countries. In reality, this places a practical limit on which spectrum channels can be used for other services, particularly in borders areas.

WRC-07 raised the status of mobile telecommunications in the 790–862MHz sub-band within Europe to be co-primary with DTT – thus giving it equal protection rights. The next World Radiocommunication Conference in 2011 will consider ongoing studies on mobile applications (e.g. wireless broadband) and other services that could be provided in that sub-band.

Against this international backdrop, the EU has worked to develop a common approach towards the digital dividend. Both the Council and European Parliament have called upon Member States to cooperate in achieving this harmonisation. The Radio Spectrum Committee issued mandates to CEPT to examine the technical considerations relating to the digital dividend, which has already resulted in three reports. CEPT working groups and project teams are also considering the rearrangement activities necessary to release a sub-band from 790–862MHz for mobile use (consistent with the WRC-07 outcome).

In November 2007 the Commission released a Communication on developing a common approach. The Commission suggested considering a harmonised set of 'clusters' of sub-bands within the entire 470–862MHz band. Following the Communication, the Council and Parliament have called for a wide and open investigation – of which this study is a part.

6 National situations within Member States

This section provides an overview and an assessment of the historical, current and future planned use of the 470–862MHz band by individual Member States. The section is structured into three time periods:

- the situation prior to the introduction of DTT
- the current situation
- the situation following ASO.

We have compared the situations in Member States with those in non-EU countries (including neighbouring countries and accession states as well as key countries outside Europe). Our assessment is based on a combination of desk research and information received in response to a questionnaire that was sent to all Member States, plus Norway and Switzerland. The information contained in this section is therefore correct as at January 2009, unless otherwise stated. We received responses from all but four Member States and would like to thank those who responded to these questionnaires. Where data is missing in this section and in the annexes, this is because we have not received the relevant information from those Member States.

More detailed information on the situation in all the analysed countries, including the responses to our questionnaire and details of our desk research, can be found in Annexes A, B and C.

6.1 Situation prior to the introduction of DTT

In many Member States, the 470–862MHz band was largely used for analogue terrestrial TV, but terrestrial TV was the most-used TV platform in less than half of the Member States (ten Member States). In 17 Member States, more than 50% of households relied primarily on cable or satellite for receiving TV on their primary TV set. These Member States were: Austria, Belgium, Bulgaria, Denmark, Estonia, Finland, Germany, Hungary, Ireland, Latvia, Luxemburg, Malta, Netherlands, Norway, Poland, Romania and Slovenia. In many of these Member States terrestrial TV was, however, critical in remote areas not served by cable TV networks.

The analogue terrestrial broadcasting landscape was also quite diverse in respect of the number of programming channels that were available prior to DTT. As shown in Figure 6.1 below, in most Member States between four and six national TV programming channels were broadcast, three or fewer were broadcast in some, while in others more than six were available. Note that this table does not include regional or local programming channels, some Member States had several of these (e.g. Germany, Spain).

Number of analogue terrestrial national TV programming channels	*Member States*
1–3	Austria, Bulgaria, Denmark, Estonia, Hungary, Netherlands, Norway, Sweden
4–6	Czech Republic, Finland, France, Germany, Ireland, Latvia, Luxembourg, Malta, Portugal, Romania, Slovakia, Slovenia, Spain, UK
>6	Cyprus, Poland

Figure 6.1: The number of analogue terrestrial national TV programming channels across Member States prior to DTT [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

Many Member States also faced restrictions on the use of some of the frequency channels in the 470–862MHz band due to international coordination issues or because some channels were reserved for other uses (e.g. for military purposes). This often limited the use of the upper part of the band (Channels 61 to 69). The historical restrictions are summarised in Figure 6.2 below.

Reason for restriction	*Member States*
No restrictions	Cyprus
Military use[92] / radio-navigation	Bulgaria (unspecified), Finland (Ch.60-69), France (Ch.66-69), Germany (Ch.61-63;67-69), Norway (unspecified), Portugal (Ch.61-69), Romania (Ch.61-69), UK (Ch.36)
Astronomy	Germany (Ch.38), Netherlands (Ch.38), UK (Ch.38)
International coordination[93]	Austria (Ch.61-69), Czech Republic (Ch.65-69), Estonia (Ch.24; Ch.54; C.61-69), Hungary (Ch.61-69), Ireland (Ch.36; Ch.38), Latvia (12 Channels mainly in the upper band), Lithuania (Ch.66-69), Netherlands(Ch.37; Ch.59)
Not specified	Denmark

Figure 6.2: The historical restrictions on use of the 470–862MHz band across Member States [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

SAB/SAP (including wireless microphones) also used the 470–862MHz band in many Member States, but use was spread widely across the whole band and often on a secondary basis to use for TV broadcasting. In most Member States, SAB/SAP could make use of interleaved spectrum in this band on a licence-exempt basis. Some Member States have dedicated specific frequency channels or sub-bands on a nationwide basis to these uses – examples include Denmark (800–820MHz), Germany (863–865MHz), Ireland (Channel 69), Malta (Channel 69), Netherlands (Channel 63), Slovakia (863–865MHz) and the UK (Channel 69).

92 Mainly Channels 61–69.

93 Including coordination with non-EU countries, such as Russia, for Eastern European Member States.

6.2 Current situation

By the end of 2008, 20 Member States had begun DTT transmissions. Ireland, Poland, Portugal, Romania, Slovakia and Slovenia plan to start digital transmissions in 2009 and Cyprus is expected to follow in 2010.

Many Member States have launched between two and eight DTT multiplexes, covering the majority of their population, with each multiplex carrying between four and seven DTT programming channels. Figure 6.3 below shows a breakdown of the number of multiplexes in individual Member States.

Number of multiplexes deployed at end of 2008	*Member States*
0	Cyprus, Ireland, Poland, Portugal, Romania, Slovenia, Slovakia
1	Belgium, Bulgaria, Denmark
2	Luxembourg
3	Austria, Czech Republic, Estonia, Hungary
4	Germany, Lithuania
5	Finland, Netherlands, Sweden
6	France, Latvia, UK
7	-
8	Italy, Malta, Spain

Figure 6.3: Number of DTT multiplexes deployed in Member States 2008 [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

In ten Member States, both free-to-view and subscription-based TV programming channels are available on DTT; in some (typically those with extensive cable TV take-up such as Austria, Denmark and Belgium), DTT is offered solely as a free-to-view service.

Figure 6.4 below illustrates the current (2008) and forecast future (2012) take up of DTT (defined as a percentage of households where DTT is the primary TV viewing platform) across selected Member States.

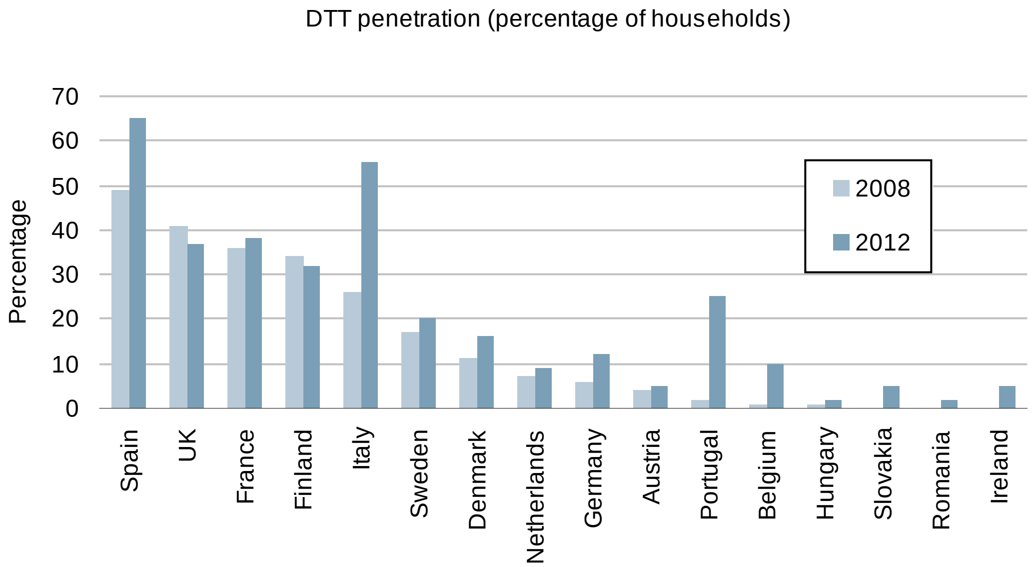

Figure 6.4: *Current and forecast DTT penetration in Member States[94] [Source: Spectrum Value Partners, 2008]*

The current GE-06 plans indicate that 14 Member States[95] have allocated or plan to allocate a multiplex for the provision of broadcast mobile TV using DVB-H technology, in addition to their existing DTT platforms.

Those Member States that launched DTT early mainly broadcast using MPEG-2 compression technology, while Member States that have recently launched, or are yet to launch (such as Ireland, Latvia, Lithuania, Romania, and Slovenia) plan to use MPEG-4 compression technology from the outset. Figure 6.5 below shows the compression technologies in use by Member States in 2008.

Austria, Denmark, Finland, Germany, Italy, Luxembourg, Portugal, Sweden and the UK all consider future migration to the MPEG-4 standard to be highly likely. In particular, Sweden and Denmark intend to simulcast using both the MPEG-2 and MPEG-4 standards in the foreseeable future.

94 Note that in the response to the Member States' questionnaire, Portugal indicated that there was zero DTT penetration, as the awarded multiplexes are not yet deployed. This differs from the data in Figure 6.4 indicating that there is a very small percentage penetration.

95 At present, Germany, Sweden, Denmark, Hungary, Italy, Netherlands, Austria, Cyprus, Czech Republic, Finland, France, Latvia, Portugal and Spain have allocated or have plans to allocate a multiplex for mobile TV services using DVB-H technology.

DTT compression technology	*Member States*
Currently using MPEG-2	Belgium, Cyprus*, Malta, Spain
Currently using MPEG-2 and will let market forces decide whether to migrate to MPEG-4 in the future	Austria, Czech Republic, Germany, Italy, Luxembourg, Netherlands
Currently using MPEG-2 but likely to migrate to MPEG-4 in the future	Denmark, Finland, Sweden, UK
Currently using MPEG-4 for some DTT transmission	Bulgaria, Estonia, France, Hungary, Ireland*, Latvia, Lithuania, Poland*, Portugal*, Romania*, Slovenia*, Slovakia*

Figure 6.5: DTT compression technologies in use across Member States in 2008 [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

*Note: * indicates countries have yet to start DTT transmission but plan to use that compression technology*

In 2005 the Commission proposed in Communication SEC(2005)661 that the beginning of 2012 be set as the target analogue switch-off (ASO) date in all Member States. Germany, Finland, Luxembourg, the Netherlands and Sweden have already completed ASO. Romania and Ireland are still developing their digital switchover (DSO) plans with the intention of completing switchover in 2012. Poland is planning ASO in 2015, but could achieve this sooner depending on market conditions.

Figure 6.6 below shows the target switch-off dates for those Member States that have a digital switchover plan.

Finland Germany Luxembourg Netherlands Sweden	Denmark Greece	Austria Estonia Malta Spain	Belgium Cyprus France Hungary Latvia	Bulgaria Czech Republic Italy Lithuania Portugal Romania Slovakia Slovenia UK
2008 (or earlier)	**2009**	**2010**	**2011**	**2012**

Figure 6.6: Expected analogue switch-off dates in Member States[96] [Source: Cocom, 2009]

96 The switch-off date of 2015 for Poland is still an estimate. Ireland is expected to switch-off by 2012, but has yet to confirm this date.

The average simulcast period for analogue and digital terrestrial TV in Member States is about 5.5 years. Smaller Member States with extensive cable infrastructure/take-up, such as the Netherlands and Luxembourg, switched off their analogue TV signals nationally overnight. Germany, as a larger nation with extensive cable infrastructure, adopted a regional digital switchover plan and had a simulcast period of almost six years. In contrast, in the UK, where terrestrial TV is one of the main TV platforms, simulcast is expected to occur for a total of 14 years prior to ASO.

6.3 Situation following analogue switch-off (ASO)

Following ASO, most Member States with the exception of Spain, Italy and Malta will have between four and ten national multiplexes. Figure 6.7 below shows the expected number of national DVB-T multiplexes and the forecast DTT penetration (again defined as the percentage of households where DTT is the primary platform) in 2012 in each Member State. Where there is no information on the forecast DTT penetration in 2012 in a Member State, it is assumed that following ASO, DTT take-up in the Member State will reach pre-DSO analogue transmission levels.

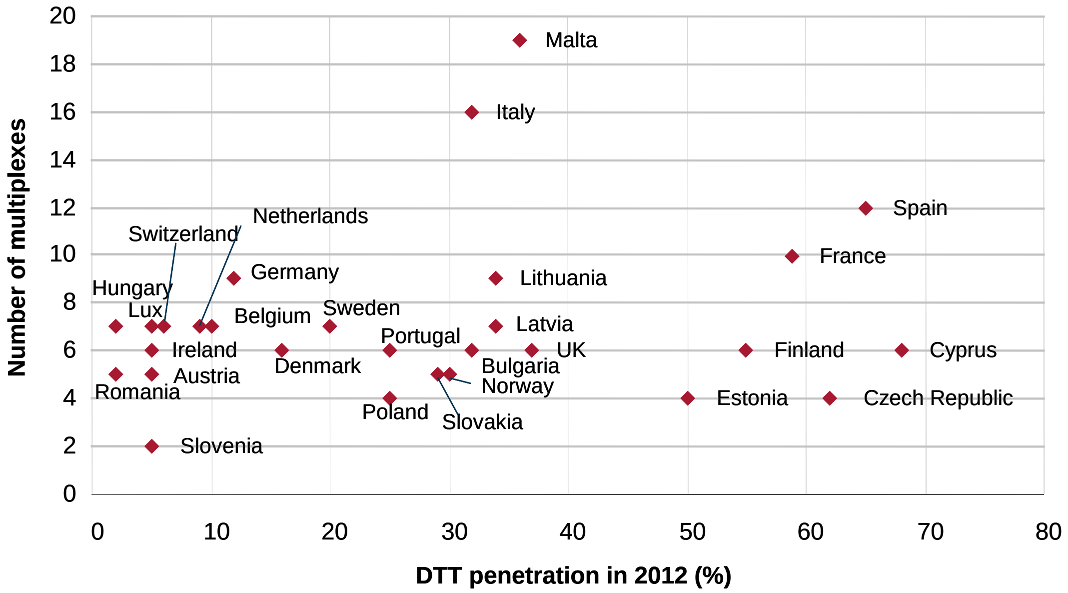

Figure 6.7: Expected number of multiplexes versus DTT penetration[97] in Member States in 2012 [Source: Spectrum Value Partners, 2008, and questionnaire responses, 2009]

97 Where forecast of digital penetration for the Member State was not available, DTT penetration was assumed to be pre-DSO analogue penetration.

It is not clear how widespread HDTV deployment will be in Member States as only some are broadcasting in HD or have set out firm plans to broadcast in HD following ASO. Other Member States will launch HDTV on a trial basis or are waiting to see how market conditions develop before committing to HDTV. Figure 6.8 below summarises the current situation regarding the availability of HDTV services over DTT across Member States.

Current situation regarding HD on the DTT platform	*Member States*
Broadcasting at least some DTT transmission in HD	France, Hungary, Latvia, Sweden*, Spain*
HDTV planned, launch of service likely in the future	Denmark, Estonia, Finland, Lithuania, Malta, Portugal, Romania, Slovakia, Slovenia, UK
Considering HD, services will be launched if market conditions are favourable	Austria, Czech Republic, Ireland, Italy, Luxembourg
Plans on HD to be decided	Belgium, Bulgaria, Cyprus, Germany, Greece, Netherlands, Poland

*Figure 6.8: Member States’ positions regarding HDTV in 2009 [Source Analysys Mason, DotEcon and Hogan & Hartson, 2009] Note * represents Member States with only regional HDTV transmissions*

Across Member States, other users of spectrum in the 470–862MHz band such as SAB/SAP, radio astronomy and military uses, will face a reduction in the amount of spectrum available as a result of the move to DTT, particularly in border regions. These applications will either be moved to a different frequency band or the equipment for these uses will have to be capable of operating over a wider frequency range. For example in the UK, Channel 69 is currently used for SAB/SAP applications, however, in order to clear Channels 61–69 (790–862MHz), Ofcom plans to move SAB/SAP to Channel 38.

The majority of Member States are still undecided on the future use of the digital dividend, and are considering various uses such as additional DTT multiplexes, wireless broadband services, SAB/SAP, and broadcast mobile TV. However, at the time of writing eight Member States (Denmark, Finland, France, Germany, the Netherlands, Spain, Sweden and the UK) and Switzerland are proposing to free up 72MHz of spectrum to adopt a 790–862MHz sub-band, and either allocate this spectrum for wireless broadband services or make it available for the market to decide the best use. The Czech Republic and Luxembourg are also contemplating freeing up the 790–862MHz sub-band. Slovakia and Hungary are considering freeing up the 790–862MHz sub-band after the ASO, however, they are dependent on non-EU neighbouring countries completing their own ASO, which may not be until 2015. In contrast, Malta plans to award all of the available spectrum to DTT. Figure 6.9 below outlines the current plans of Member States for the 790–862MHz sub-band.

Current plans for 790–862MHz frequency range post DSO[98]	*Member States*
Making this sub-band available for wireless broadband or other services	Denmark, Finland, France, Germany, the Netherlands, Spain, Sweden and the UK
Considering making this sub-band available for wireless broadband or other services	The Czech Republic, Ireland, Luxembourg, Hungary and Slovakia
Undecided on the use of the 790–862MHz frequency range	Austria, Belgium, Bulgaria, Cyprus, Estonia, Greece, Italy, Latvia, Lithuania, Poland, Portugal, Romania and Slovenia
Plans to award all of the digital dividend to DTT	Malta

Figure 6.9: The plans of Member States for the use of the 790–862MHz sub-band (as of December 2008) [Source Analysys Mason, DotEcon and Hogan & Hartson, 2009][99]

In the Czech Republic, France, and the UK, an auction is likely to be used to award the digital dividend, while Slovenia and Slovakia are likely to use a comparative selection (beauty contest) approach. Although Finland and Germany have decided to make the 790–862MHz sub-band available for wireless broadband services, they have not made decisions on the award process that will be used. The French and UK regulators have already started consultation processes on the award mechanism for the digital dividend, with France aiming to launch this award process by the end of 2009 and the UK aiming to award its digital dividend during 2010.

6.4 Legal, regulatory and policy constraints on use of the UHF band

The Community has adopted a general framework that applies to authorisations (including authorisations for TV broadcast distribution) under the Authorisation Directive 2002/20/EC. However, there are significant differences in the way Member States have implemented this framework into national law. Notably, Member States have implemented authorisations differently because of domestic priorities, for example in France DTT authorisations have been allocated on the basis of beauty contests in order to guarantee pluralism. Some Member States have, for instance, put constraints on authorisation terms, which would still be in effect after the ASO, and some amendments to the legislation or regulatory acts may be required (e.g. in Austria). Such issues must be overcome before the ASO occurs, otherwise Member States may face difficulties in meeting their own ASO target (as well as the target envisaged by the Commission).

These differences may impact the potential scope for a coordinated approach between Member States, especially over ASO timing, as well as a Member State's ability to free some spectrum within the 470–862MHz band.

98 Based both on questionnaire responses from January 2009 and more recent announcements made by SMAs.

99 Information for Belgium, Italy, Greece and Poland is not available.

Member States have also set differing domestic policy priorities, which could limit the incentive for current licensees to optimise the use of spectrum or limit the amount of spectrum that can be freed-up under the DSO process. Such differences are illustrated by Figure 6.10 below.

Domestic policy priorities	*Member States*
Not specified/available/decided	Belgium, Bulgaria, Cyprus, Denmark, Estonia, Finland, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Slovenia
Pluralism	Austria, France, Hungary, Malta, Portugal, Romania, Spain
Multilingual/regional services	France, Germany, Malta, Portugal, Spain, Sweden
Increase of DTT population coverage	Austria, France, Romania, Slovakia
Reduction of the digital divide	France, Germany
Launch of new technologies/services (e.g. HDTV or mobile TV)	France, Hungary, Portugal, Romania, Slovakia, UK

Figure 6.10: Domestic policy priorities across Member States [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

6.5 Comparison with non-EU countries

This section highlights the main similarities and differences regarding the DSO and ASO of some non-EU countries when compared to Member States, as well as the main political and economical decisions that are affecting the digital dividend in these countries and which may, to some extent, impact Member States.

6.5.1 Neighbouring countries/accession states

This section summarises the situation regarding the digital dividend in the following neighbouring countries and accession states: Croatia, Norway, Russia, Switzerland and Turkey. More information on these countries can be found in Annex B. Note that a representative selection of countries have been considered, including those that could be considered as being influential on EU Member States (e.g. Russia).

Two main decisions made in these countries may impact on the ability of some Member States to implement or even benefit from the digital dividend, as well as on the overall scope for and benefits from a coordinated approach among Member States:

- the timing of their ASO
- the decisions on potential uses of the 470–862MHz band.

Regard the timing of ASO, the target dates set in these five countries vary between 2008 and 2018 (as illustrated by Figure 6.11 below), and some countries (notably Russia and Turkey) are not aligned with the general plans of EU Member States to complete the ASO by 2012.

Given that the simulcast period is quite long, complex (in terms of frequency planning) and requires the extensive use of spectrum, some Member States (especially in Eastern Europe) believe they cannot make the digital dividend available until Eastern neighbours (including Russia) have completed their DSO. Alignment between EU and neighbouring countries may then be critical.

Country	*ASO target*
Switzerland	2008[100]
Norway	End of 2009
Croatia	January 2011
Russia	Late 2015
Turkey	2018

Figure 6.11: ASO targets in EU neighbouring countries/accession States [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

As illustrated in Figure 6.12 below, decisions taken by Croatia and Switzerland on the future use of the digital dividend (including the launch of new services within the 470–862MHz band), have indicated that both countries intend to allocate the 790–862MHz sub-band to wireless broadband. Norway has also decided to make 790–862MHz available but its future use will be determined by beauty contest. The lack of clarity over the plans of Russia and Turkey may impact on Eastern European Member States.

Country	*Digital dividend allocation plan*
Croatia	The 790–862MHz sub-band will be allocated to wireless broadband services.
Norway	The band 790–862MHz will be allocated via a beauty contest. Further TV programming channels and wireless broadband services are considered likely candidates.
Russia	No decision taken yet. However it is unlikely that the band 790–862MHz will be released before 2015 (it is currently used for military services).
Switzerland	The 790–862MHz sub-band will be allocated to wireless broadband services. The regulator, Bakom, expects the implementation of such services to be possible before 2015.
Turkey	No decision taken yet. DSO will be completed by 2018.

Figure 6.12: Digital dividend allocation plans in EU neighbouring countries/accession States [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

100 Except in some mountainous areas where it will be in 2009.

6.5.2 Countries outside Europe

This section summarises the situation regarding the digital dividend in the following major markets. More information on these countries can be found in Annex C:

- China
- Japan
- South Korea
- the USA.

Two main decisions made in these countries may impact the total benefit to Member States from the digital dividend:

- the decisions on potential uses of the 470–862MHz band
- the technical/standard choices regarding DTT.

China has not yet taken a decision regarding the digital dividend. Japan, South Korea and the USA are favouring its use for wireless broadband. However, this would involve different spectrum bands ins each country (see Figure 6.13 below) as well as deviating from the 790–862MHz sub-band that is being proposed in Europe.

Country	*Digital dividend allocation plan*
China	The DSO process started only recently in China and ASO is expected to occur by 2015. No decision regarding the digital dividend has yet been taken.
Japan	The ASO is expected to occur in July 2011. The Ministry of Internal Affairs and Communication (MIC) assessed that 60MHz will be freed up in the 470–862MHz band (710–770MHz) and allocated to electronic communications. As of February 2009, the timetable for awarding the spectrum was not yet fixed but according to a communication issued in 2007[101], it should be awarded for FDD applications. Also, in view of current policy priorities in Japan to promote HD and mobile TV, the MIC does not expect any increase in the number of DTT programming channels.
South Korea	ASO is expected to occur by 31 December 2012. South Korea identified 54MHz of the UHF band for their digital dividend (752-806MHz). It has yet to be decided how this spectrum will be awarded.
USA	ASO was completed in June 2009. 108MHz of the 470–862MHz band was released. 24MHz is allocated to PPDR (Channels 63, 64, 68 and 69). 84MHz has been awarded though auctions (including 62MHz in the 700MHz band), as illustrated in Figure 6.14 below. Overall the FCC awarded: • 3 lots of 2×6MHz (698–716MHz; 728–746MHz) • 1 lot of 2×11MHz (746–757MHz; 776–787MHz) • 1 lot of 2×5MHz (758–763MHz; 788–793MHz) • 2 lots of 2×1MHz • 2 lots of 6MHz TDD spectrum (710–722MHz) • 763–775MHz and 793–805MHz have been allocated to public safety services (PPDR). Verizon plans to deploy a mobile broadband network with the spectrum it acquired on a national basis (using LTE technology). Qualcomm is expected to use its spectrum to extend its existing MediaFLO broadcast mobile TV system.

Figure 6.13: Digital dividend allocation plans in selected non-European countries [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

101 Communications Policy and ITS in Japan, MORI Takashi (10 October 2007).

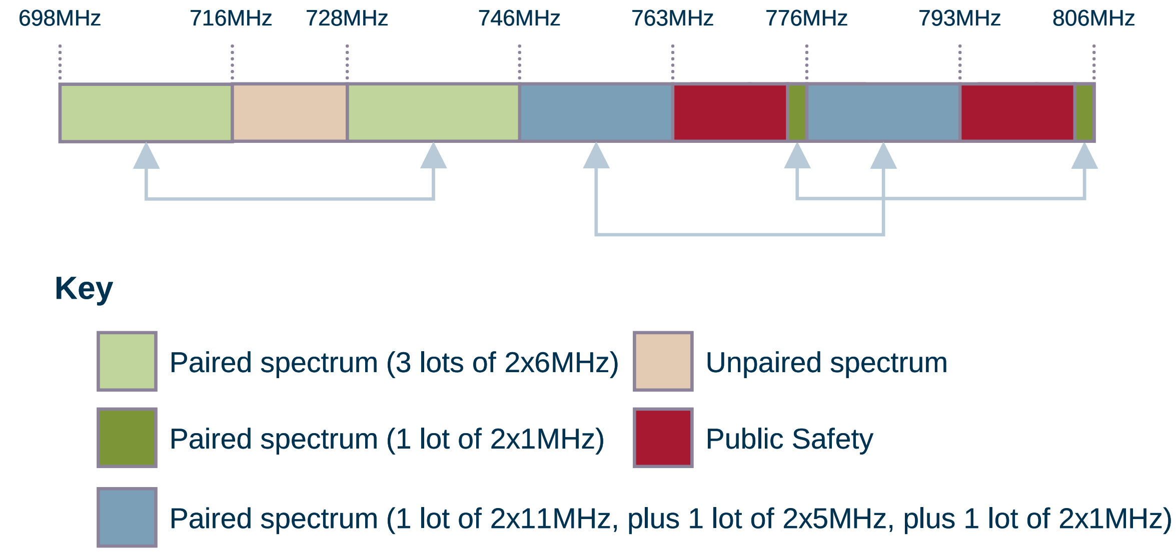

Figure 6.14: Revised 700MHz band (698–806MHz) plan in the USA following 2008 auctions [Source: FCC, September 2007]

Member States could potentially benefit from economies of scale if they were to follow band plans in these markets. In particular, it may be possible for Member States wishing to make a second sub-band below 790MHz available for wireless broadband service, to align with part of the 700MHz band plan in the USA (698–716MHz paired with 728–746MHz, or 746–760MHz paired with 776–790MHz). Another option may be to align to a band plan in Japan which will be in the 710–770MHz range.

From a technical point of view, the technical/standards choices made by these countries (either because they are advanced in the DSO process or because they represent significant markets for manufacturers), may also impact the economies of scale that Member States could expect from harmonisation with these countries.

- Ericsson and Alcatel-Lucent will deploy a mobile broadband network for Verizon Wireless in the USA using LTE technology in the 700MHz band[102], which Verizon expects will begin commercial service in 2010.
- The Advanced Television Systems Committee (ATSC) DTT standard has been deployed across North America and Mexico.
- Japan is strongly promoting HDTV and mobile TV. The policy in favour of the development of HDTV is linked to Japan's industrial policy of promotion of the ISDB-T technology (an alternative digital TV technology to DVB-T). This technology supports the broadcast of

102 Jethro Mullen (18 February 2009), "Verizon picks Ericsson, Alcatel-Lucent for LTE network".

HDTV content without having to simulcast SDTV alongside HDTV. The policy on mobile TV is to reserve one of the 13 segments of a 6MHz channel used by each ISDB-T multiplex for broadcast mobile TV. At present, content for mobile TV services is identical to that for fixed TV. However, a law adopted in 2007 allows broadcasters to offer different content for broadcast mobile TV services.

- South Korea is one of the few countries outside of North America to have deployed the ATSC DTT standard. For broadcast mobile TV, the DMB standard has been deployed.

6.6 Summary

As we have seen, Member States have varying approaches to their DSO plans. The pace at which they are being executed appears to depend on geography, the television platform landscape, policy objectives and political will, as well as the level of technological advancement. In general, Western European Member States have started, and are likely to complete, their DSO before Eastern European Member States. Indeed, five (Finland, Germany, Luxembourg, the Netherlands and Sweden) have already switched off their analogue transmissions.

Member States that have completed their DSO early may have the use of their digital dividend constrained by neighbouring Member States that have not completed DSO. This constraint is due to the potential for harmful interference of analogue transmissions from neighbouring Member States, but has been mitigated by the Commission's Communication SEC(2005)661 that proposes that Member States complete their DSO by 2012. However, Member States such as Finland, Estonia and Romania that border non-EU countries such as Russia (its ASO is planned for 2015) will still face potential interference issues until their neighbours have completed their DSO. As Poland is also likely to complete ASO after 2012 (its ASO is also anticipated to be 2015) it could affect its neighbours in the same way.

Regarding the 790–862MHz sub-band, eight Member States (Denmark, Finland, France, Germany, the Netherlands, Spain, Sweden and the UK) are committed to plans to make this available for wireless broadband services. At the same time one Member State (Malta) plans to continue using all of the 470–862MHz spectrum for DTT. Six Member States (the Czech Republic, Ireland, Latvia, Luxembourg, Hungary and Slovakia) are considering adopting the sub-band but have yet to make a decision. The remaining 12 Member States have yet to consider the future use of the 790–862MHz sub-band.

Decisions on whether to adopt the sub-band by the 18 undecided Member States will impact the benefits realised from the sub-band across the EU. The more widely it is adopted the larger the benefits of economies of scale and roaming.

Part B: Factors influencing the use of the digital dividend

7 Technical constraints on the use of the 470–862MHz band

In this section we outline the spectrum requirements of each potential use, then summarise the findings of technical studies into interference issues surrounding to the use of the digital dividend. In general, there are two types of interference that might occur: interference between systems operating in *neighbouring* frequency bands (*adjacent channel interference*), and systems operating in the *same* frequency band but in different geographic areas (*co-channel interference*). For the 470–862MHz band, two main issues therefore arise:

- the combination of different potential uses of digital dividend spectrum and how these uses might co-exist in neighbouring frequency bands (i.e. the potential for adjacent channel interference to occur)

- interference in border areas caused by systems in one country using the same frequency band as those in the neighbouring country, either for the same or a different use (i.e. co-channel interference).

Note that under the GE-06 Agreement, alternative uses to DTT are allowed, provided that they meet the technical conditions specified in the plan. Therefore, coordinating broadcasting and wireless broadband services across borders might be necessary (for example, if one country is using channels in the 470–862MHz band for broadcasting transmission whereas another is using the same channels for a wireless broadband service).

7.1 Spectrum requirements of each use

Each of the potential uses identified in Section 4.1 has different spectrum requirements, which is determined by its purpose, the technologies used and network and receiver design, amongst other factors.

In Figure 7.1 below, we highlight the constraints in terms of spectrum requirements for each potential use. We show:

- the typical minimum channel width required
- an indication of the typical total quantity of spectrum required per spectrum user in the 470–862MHz band
- any other requirements.

Use	*Channel width* *(of a single channel)*	*Typical quantity of spectrum per operator*	*Other requirements*
DTT	8MHz	8MHz for a national SFN Up to 96MHz (i.e. up to 12 channels) for an MFN	International coordination requirements are covered by the GE-06 Agreement and related bilateral/multilateral agreements
Broadcast mobile TV	8MHz	8–24MHz, depending whether SFN or MFN	Requirement for contiguous bands will depend on network configuration (i.e. SFN or MFN)
Wireless broadband	Depends on the technology used, for example: UMTS: 2×5MHz paired channels (future LTE: scalable from 2×1.25MHz to 2×20MHz) WiMAX: Unpaired channels from 1.25MHz to 20MHz (depending on required data rate)	Up to 40MHz	Requires spectrum in contiguous bands
SAB/SAP	200kHz (typical channel width for wireless microphones, talkback systems and portable audio links)	Variable, depending on number of devices in operation in the same geographic area. Large productions (e.g. pop concerts) may require more than 50 200kHz channels, though most applications need either one or a small number of channels	Talkback systems are sometimes two-way duplex (e.g. 80MHz typical duplex spacing).
PPDR	25kHz, 50kHz, 100kHz or 150kHz for TETRA TEDS (depending on the data rate required)[103]	Up to 2×15MHz[104]	Detailed technical characteristics and standards not defined at this stage
Cognitive radio	To operate within interleaved spectrum, total spectral bandwidth is limited to 8MHz[105]	N×8MHz	Detailed technical characteristics and standards not defined at this stage

Figure 7.1: Spectrum requirements for different prospective uses [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

103 It should be noted that TETRA-2 (TEDS) systems may share control channel(s) with TETRA-1 and therefore would need to operate in a common bandwidth e.g. a TETRA-2 system may require to use a TETRA-1 control channel operating in the band 380–400MHz.

104 An estimate from WIK Consult (2008), "Safety first – Reinvesting the digital dividend in safeguarding citizens".

105 For example, see WINLAB (undated), "Service Discovery and Device Identification in Cognitive Radio Networks".

7.2 Adjacent channel compatibility

Adjacent channel interference (ACI) refers to the situation in which a service operating in a particular frequency channel interferes with reception of another service operating in an immediately adjacent channel, or beyond. Radio equipment specifications normally include performance characteristics necessary to limit the impact of ACI, through parameters such as adjacent channel selectivity, or adjacent channel leakage ratio . Adjacent channel selectivity relates to the ability of radio receivers to select the intended transmission, and to reject others. Adjacent channel leakage ratio refers to the signal level that a radio transmitter is allowed to produce in adjacent channels, relative to the power level of its intended transmission. In practice, ACI can still occur, and in some cases mitigation, such as guard bands, may be required between different types of uses.

Below we review work undertaken on ACI by CEPT and by SMAs. We then discuss other ACI issues in the 470–862MHz band, such as the susceptibility of DTT receivers to transmissions that are nine 8MHz spectrum channels above the channel in use (known as the ‘image’ or ‘n+9’ channel).

7.2.1 Research undertaken by CEPT

SMAs allocate spectrum bands to various services within the international framework set by the ITU, as well as in accordance with EU policy as determined by the Commission. CEPT plays an important role in coordinating European input to the ITU, and preparing the necessary technical conditions relating to European frequency allocation and use. Their work includes the study of the potential ACI between different spectrum uses operating in neighbouring bands in order to ascertain the potential for harmful interference and any necessary mitigation.

As stated in Section 5.3, the RSC has issued two mandates to CEPT. The first mandate was issued in January 2007, and was on technical considerations regarding harmonisation options for the digital dividend; it resulted in three CEPT reports prepared by ECC TG4. The second mandate, intended as a follow-up to the first, was issued in April 2008. The ECC TG4, ECC PT1 and CEPT Project Team (PT) SE42 (a spectrum engineering working group of CEPT) were completing work in response to this second mandate at the time of producing this report.

In response to the first mandate, CEPT produced three reports (Report A, Report B and Report C), which provide detailed analyses of all of the key adjacent band compatibility scenarios identified for the 470–862MHz band. The title and objective of each of these three reports is summarised in Figure 7.2 below.

Report title	*Objective*
CEPT Report 21 – Report A 'Compatibility issues between mobile power transmitter networks and larger coverage/high power/tower type of networks' (July 2008)	To consider approaches to implement wireless broadband/mobile TV **downlinks**[106] in the UHF spectrum 470–862MHz, considering the adjacent channel compatibility issues that might arise with DTT and how these might be resolved or mitigated: - to assess the practical coexistence between high and low-power density networks[107] - to assess the possibility of harmonising at EU level a sub-band for multimedia applications, while minimising the impact on the GE-06 plan
CEPT Report 22 – Report B 'Technical feasibility of harmonising a sub-band of Bands IV and V for fixed/mobile applications (including uplinks)'	To consider approaches to implementing two-way fixed/mobile systems i.e. systems incorporating **uplinks and downlinks**, in the 470–862MHz band and the associated adjacent channel interference issues that this creates with DTT.
CEPT Report 24 – Report C 'Preliminary assessment of the feasibility of future applications into white spaces between allotments`	To consider the practical implementation of new/future applications within the interleaved (white space) spectrum in the 470–862MHz band

Figure 7.2: A summary of the objectives of CEPT ACI studies in response to the RSC's first mandate

These reports cover adjacent channel compatibility between:

- medium-power, one-way technologies (e.g. broadcast mobile TV) and high-power, one-way (e.g. DTT)
- medium-power, two-way technologies (either FDD or TDD) and high-power, one-way (e.g. DTT)
- future applications such as cognitive radio.

We note that the compatibility issues relating to SAB/SAP were not considered in the initial reports, but are being addressed in subsequent work. A summary of the key results in each area is provided in Figure 7.3 below.

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106 Downlink refers to either the transmission path from a transmitter in a mobile broadcasting network (e.g. DVB-H) transmitting to a mobile handheld device, or alternatively from a base station in a mobile cellular or wireless broadband network transmitting to a user device. The 'return' path (the so-called uplink from the device back to the network) is not covered in Report A and is the subject of Report B.

107 i.e. RPC-1 and RPC-2/3 configurations as stated in GE-06 in adjacent channels.

Compatibility scenario	*Conclusions*
Broadcast mobile TV and DTT	1. Broadcast mobile TV networks can use the GE-06 plan, assuming that the technical characteristics of the broadcast mobile TV network do not cause any more interference than that defined for DTT within the plan. 2. Different mitigation methods can be used on an area-by-area basis to minimise the impact of ACI. The best transmitting configuration to cover the same area is to co-site transmitters and to use the same antenna system. The most difficult configuration is to use different and widely separated sites. 3. ACI is most problematic in the first adjacent channel (i.e. 8MHz offset between carrier centre frequencies). 4. The risk of ACI (to DTT receivers) exists mainly in the close vicinity of the interfering mobile TV transmitter, located within the DTT coverage area. 5. Co-existence of mobile TV or wireless broadband with high-power/high-tower networks in 470–862MHz is possible within the GE-06 Agreement by applying the available mitigation techniques and by careful network planning.
DTT and wireless broadband	1. Harmonisation of a sub-band for wireless broadband is feasible from a technical, regulatory and administrative point of view. 2. The harmonised sub-band should include Channels 61–69 (790–862MHz). 3. The level of interference likely to arise from the implementation of GE-06 plan entries makes it virtually impossible for any (European) country to start using a harmonised sub-band for wireless broadband without the agreement of neighbouring countries (i.e. in the form of bilateral or multilateral agreements). 4. Uplink paths are not covered by the GE-06 Agreement and consequently ‘not protected’ by ITU coordination (i.e. there is no provision for notifying wireless broadband transmitting stations in the GE-06 Agreement). 5. Regarding the potential for ACI, no guard band is needed to protect DTT from wireless broadband downlinks, which can be managed through careful planning and mitigation. Conversely, a two-channel frequency separation (16MHz) is recommended to provide protection to and from wireless broadband uplinks.[108] For this reason, subsequent work to define harmonised band plans for wireless broadband use of the 790–862MHz sub-band places the FDD uplink at the upper part of the band (which is opposite to the normal convention), to provide the necessary frequency separation with DTT. Since uplinks and downlinks in a TDD system transmit within the same frequency channel, separating the uplink and DTT is not possible using the channel plan alone and so a specific guard band is necessary. In Figure 5.2 of this report we illustrate the guard band that ECC PT1 is now proposing between DTT and TDD wireless broadband, which is 7MHz. 6. ACI from wireless broadband downlinks to DVB-T reception occurs if the difference in field strength (between the wireless broadband base station and the DVB-T service) is too large, which results in so-called ‘hole punching’ of the DVB-T coverage in areas around the mobile base station (this problem is worst at the edge of a DVB-T coverage area where the DVB-T signal strength is at its lowest and DVB-T receivers are therefore most prone to interference from other transmissions).

108 The recommendation for a guard band to protect wireless broadband uplinks arises primarily as a result of the protection level afforded to DVB-T reception in the GE-06 plan being insufficient to protect IMT base stations. Therefore, frequency separation is needed so not to exceed the out of band blocking level of an IMT base station.

Feasibility of using white space for cognitive radio applications	1. The spectrum capacity offered by interleaved spectrum (white space) will depend on the use of the spectrum by primary services and so is highly variable based upon national implementations. 2. Interleaved spectrum availability is being gradually reduced as a result of the GE-06 Agreement and WRC-07 decisions. 3. Controlled access to SAB/SAP uses within interleaved spectrum is expected to continue in most CEPT countries. 4. The feasibility of cognitive sharing schemes has not yet been conclusively demonstrated, as it is too early in the technical development cycle to judge the final capabilities of these technologies.

Figure 7.3: A summary of the conclusions of CEPT's Reports A, B and C in relation to adjacent channel compatibility issues [Source: Analysys Mason]

In response to the Commission's second mandate, ECC TG4, ECC PT1 and CEPT PT SE42 are working on a series of studies. These are primarily related to:

- guidelines on cross-border issues between wireless broadband services in one country and broadcasting services in another country (a co-channel interference issue briefly discussed Section 7.3 below) – this takes into account the need to define cross-border coordination requirements within the 790–862MHz sub-band
- recommendations on the best approach to the continued SAB/SAP operation alongside DTT in 470–862MHz
- draft guidelines for the implementation of the 790–862MHz sub-band, including a draft ECC decision on harmonised band plans for FDD and TDD wireless broadband implementation (At the time of producing this report, a draft CEPT report has been completed outlining proposed band plans for the 790–862MHz sub-band; discussed in more detail in Section 5.3.2.)
- block edge masks (BEMs): a BEM is a technical mask that defines the permitted power levels that a radio system can transmit within its own band and in neighbouring bands, specified as a field strength within a defined channel width, without prescribing any specific technology types (At the time of writing, draft BEMs had been developed within CEPT PT SE42 to complement the proposed CEPT FDD and TDD band plans for the 790–862MHz sub-band.)
- protection ratios to prevent broadcast services being subject to interference from wireless broadband services.

CEPT PT SE42 met in May 2009 and completed a draft ECC report on least restrictive technical conditions (BEMs) for use of the 790–862MHz sub-band. This is consistent with the Commission's WAPECS concept and complements the BEMs already developed for other frequency bands (e.g. 2.6GHz) in CEPT Report 19. One further CEPT study related to thee digital dividend is addressing aspects relating to the continued use of 470–862MHz by SAB/SAP, including compatibility issues with other services. We note the following interim statements contained within a recent version of the draft report.[109]

- Terminals of wireless broadband networks operating in the 790–862MHz sub-band will not cause harmful ACI to wireless microphones provided that the necessary isolation exists (e.g. the two devices are not operating in close proximity).

- SAB/SAP already co-exists well using adjacent channels or when interleaved with analogue TV and it is expected that it can continue to operate on an interleaved basis with DTT. This is providing that SAB/SAP use is subject to restrictions on operating power and coordination of specific assignments to avoid interference to DTT reception in areas adjacent to SAB/SAP locations.

- In most instances SAB/SAP will be able to operate in the channel immediately adjacent to DTT (this issue is discussed further in Section 7.4 below).

Digital dividend spectrum has also been studied within CEPT Report 19, which CEPT prepared in 2007 in response to the Commission's mandate on WAPECS. CEPT Report 19 notes the following points.

- The GE-06 Agreement introduces some level of flexibility for introducing services other than broadcasting within 470–862MHz, providing the interference and protection requirements are kept within the envelope of the plan.

- The preferred option for implementation of wireless broadband services (including uplinks) is the establishment of a specific sub-band, recommended to be within the upper part of this range, consistent with the results of WRC-07 (which allocated 790–862MHz to mobile services in Region 1).

- In order to determine the least restrictive technical conditions for wireless broadband services using digital dividend spectrum, further work is required to develop appropriate block edge masks consistent with the Commission's WAPECS concept.

7.2.2 Research undertaken by SMAs regarding ACI

The SMA that appears to have conducted the most work regarding ACI in the 470–792MHz sub-band is Ofcom (UK). In its consultation document of August 2008, 'Digital Dividend Review: 550–630MHz and 790–854MHz'[110], Ofcom makes a number of proposals relating to guard bands between different potential uses of the digital dividend. These have been developed based upon the

[109] TG4 (08)240_Annex 1

[110] Ofcom (August 2008), 'Digital Dividend Review: 550–630MHz and 790–854MHz'.

results of ECC TG4's work as well as previous technical studies undertaken by Analysys Mason for Ofcom; they are summarised in Figure 7.4 below.

Adjacent services	*Guard bands (MHz)*
Between like services	No guard band
DVB-T/broadcast mobile TV	5MHz
DVB-T/ wireless broadband FDD downlink	5MHz
DVB-T/ wireless broadband FDD uplink	16MHz
DVB-T/ wireless broadband TDD	16MHz
Broadcast mobile TV / wireless broadband FDD downlink	5MHz
Broadcast mobile TV / wireless broadband FDD uplink	19MHz
Broadcast mobile TV / wireless broadband TDD	19MHz
Wireless broadband FDD downlink / wireless broadband TDD	5MHz
Wireless broadband FDD downlink / wireless broadband FDD uplink	10MHz
Wireless broadband FDD uplink / wireless broadband TDD	5MHz

Figure 7.4: Proposed guard bands between alternative services operating in digital dividend spectrum [Source: Ofcom, 2008]

These results are consistent with the findings of CEPT. Both conclude that a sizeable frequency separation (16MHz) would be required between DTT and wireless broadband uplinks. However, Ofcom suggests that a 5MHz guard band is required between DTT and FDD wireless broadband downlinks, while CEPT suggests that no guard band is required as long as careful planning and mitigating steps are taken. We are not aware of any similar work to define frequency separation distances between potential uses of the digital dividend in other Member States.

The most problematic interference scenario appears to be the potential for DTT transmitters to interfere with wireless broadband downlinks. In the draft ECC PT1 FDD band plan, the downlink is positioned at the lower end of the band (at 790MHz), beside DTT use. This has the benefit of separating DTT receivers from wireless broadband uplinks (i.e. mobile terminals interfering with DTT receivers) but could give rise to interference with the corresponding wireless broadband downlink.

7.2.3 Other ACI issues

This section briefly discusses two further ACI issues regarding 470–862MHz that are not discussed in the above reports:

- ACI between different DTT transmissions in adjacent channels
- the susceptibility of DTT receivers to transmissions nine spectrum channels above.

ACI between different DTT transmissions in adjacent channels

There is potential for DTT transmissions in adjacent channels to interfere with each other if the systems are not planned to avoid this. Such interference is usually managed through frequency planning by the national broadcaster or transmission network operator(s), and therefore is not a problem in practice. Frequency planning will take account of the feasibility of using adjacent channels in neighbouring coverage areas, and plan transmitter power levels appropriately to enable the best use of frequencies.

The susceptibility of DTT receivers to transmissions nine spectrum channels above

Some DTT receivers are susceptible to interference from transmissions nine 8MHz spectrum channels above the intended spectrum channel. This is often referred to as the 'image channel' or the 'n+9 channel'.[111] This means that, for a particular channel, if a transmitter site (for DTT or any other service) were deployed in the n+9 channel, there may be an area around the transmitter site where that DTT signal could not be received.

Studies have suggested that the susceptibility of DTT receivers[112] to this effect varies between different receiver types[113]. Research undertaken by the BBC illustrates this issue (see Figure 7.5 below).

111 Most radio receivers make use of the 'super-heterodyne' principle, in which the received frequency is converted to a second, fixed, intermediate frequency (IF), by mixing it with a locally generated signal at the required frequency difference. For example, if the receive frequency is 600MHz, and the IF frequency is 39.5MHz, the conversion can be effected by mixing the incoming signal with a local oscillator (LO) signal of 639.5MHz. Unfortunately, in this arrangement, not only is the wanted signal at 600MHz (LO-IF) converted to the IF, but also any signal at 679MHz (LO+IF). This spurious response can be only partially rejected by additional filtering. This spurious response is referred to as the image channel, and is evident at n+9.

112 Measured as the n+9 image carrier-to-interference (C/I) protection ratio values.

113 For example, see ERA Technology for Ofcom (October 2007), "Conducted Measurements to Quantify DVB-T Interference into DTT Receivers" . (http://www.ofcom.org.uk/consult/condocs/ddr/statement/ERA2.pdf)

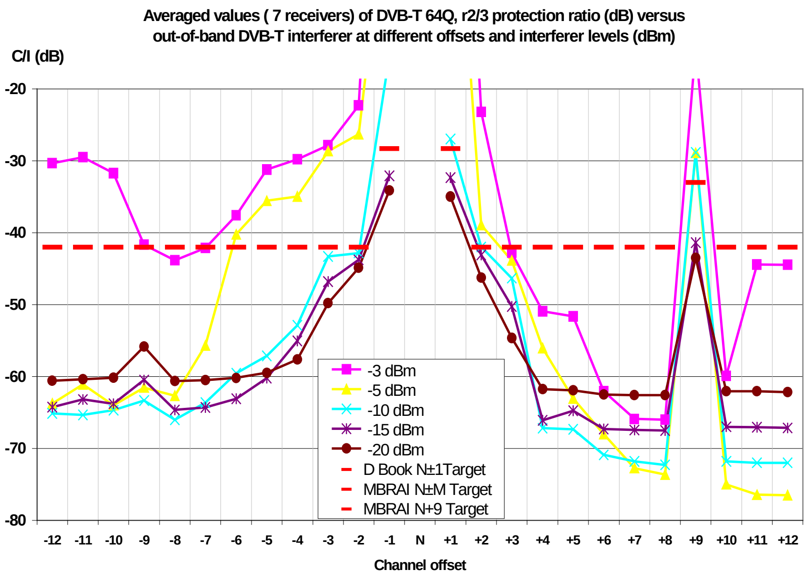

Figure 7.5: Adjacent channel performance of DTT receiver [Source BBC]

Generally, a higher protection ratio is required nine channels above DTT transmission to protect DTT receivers from n+9 channel interference. New services using digital dividend spectrum may therefore have n+9 channel implications for DTT services. For example, wireless broadband systems used in the 790–862MHz sub-band (Channels 62–69) may have implications for DTT use in Channels 53–60.

n+9 channel interference could be mitigated in two ways in the future:

- by ensuring that a sufficient difference exists between the wanted DTT and the unwanted (interfering) signal (i.e. that the strength of the wanted signal is greater than the interfering signal by the required margin to allow proper receiver operation) – this can be achieved by ensuring a minimum physical distance between a wireless broadband device and a DTT receiver

- by ensuring that all DTT receivers meet minimum standards regarding their n+9 channel response.

7.3 Co-channel compatibility

'Co-channel' means two radio systems operating using the same frequency channel but in different geographical areas. Co-channel interference refers to a situation where interference from the transmitter of one such system is experienced by the receiver of the other. Co-channel interference is usually avoided by ensuring a minimum physical separation, either within a country (e.g. two regional systems re-using the same frequency in different geographic area), or neighbouring countries (e.g. for the purposes of cross-border coordination).

In the case of cross-border coordination, geographical separation is not always possible (since operators may wish to deploy services up to the border with the neighbouring country). In this case therefore, other forms of interference management, such as maximum field strength limits, can be applied.

Below we outline the emission levels that are permitted by the GE-06 Agreement, before discussing the impact this may have on potential deployments in neighbouring countries. Finally, we discuss mitigation steps that could be take to avoid cross-border interference from DTT to wireless broadband – which we consider to be the largest co-channel interference concern.

7.3.1 Emission levels permitted by GE-06

Co-channel interference between broadcasting networks in one country and those in its neighbours needs to be carefully managed in the 470–862MHz band. The GE-06 Agreement provides the basis for doing this. It provides coordination trigger field strengths for the protection of broadcasting and other primary services. Signatories can agree to different parameters through bilateral or multilateral agreements if they so wish, as explained in Section 5.2.1 above.

The area and the population of a Member State that will be affected by DTT transmissions in neighbouring countries (including both Member States and non-EU countries) depends on a number of factors:

- the physical size, shape and length of borders of the Member State
- the location of the population, especially whether it is focused near border areas
- the topology of the DTT network in the neighbouring countries.

The exact areas that will be affected have not been studied widely across Europe, however, a study conducted by Analysys Mason for Ofcom (UK) as part of their Digital Dividend Review did consider this issue for the UK.[114] The graphs in Figure 7.6 and Figure 7.7 below show the percentage area of the UK affected by levels of incoming interference from DTT transmission in neighbouring countries (Belgium, France, the Netherlands and Ireland) for different spectrum channels. These graphs highlight the results for each of the spectrum channels that Ofcom had identified (at that stage) for release.[115]

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[114] Analysys Mason for Ofcom (2007), study on international interference in UHF Bands IV and V.

[115] It should be noted that these are worst-case graphs (mapped using the propagation models and receiver heights for interference prediction as specified within the GE-06 plan). In practice, use of more accurate modelling using specific terrain, urban clutter and actual receiver height will most likely reduce the expected interference, compared to these worst-case results.

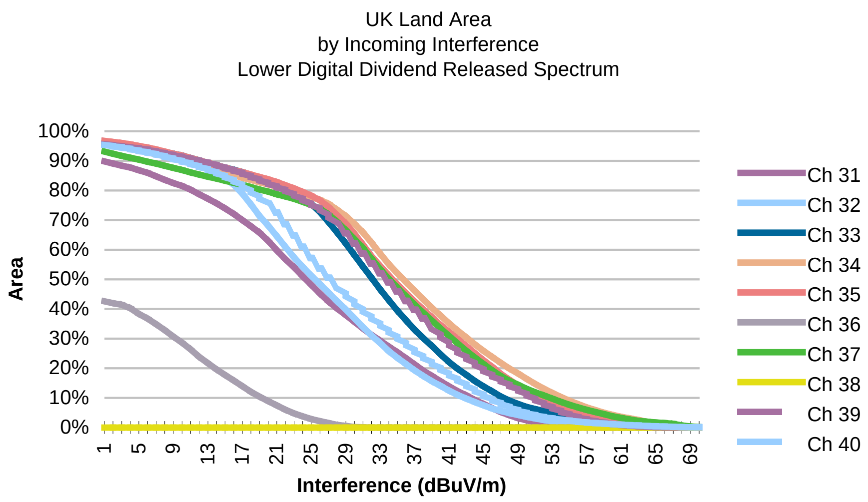

Figure 7.6: Area affected by incoming interference – Channels 31–40 [Source: Analysys Mason, 2007]

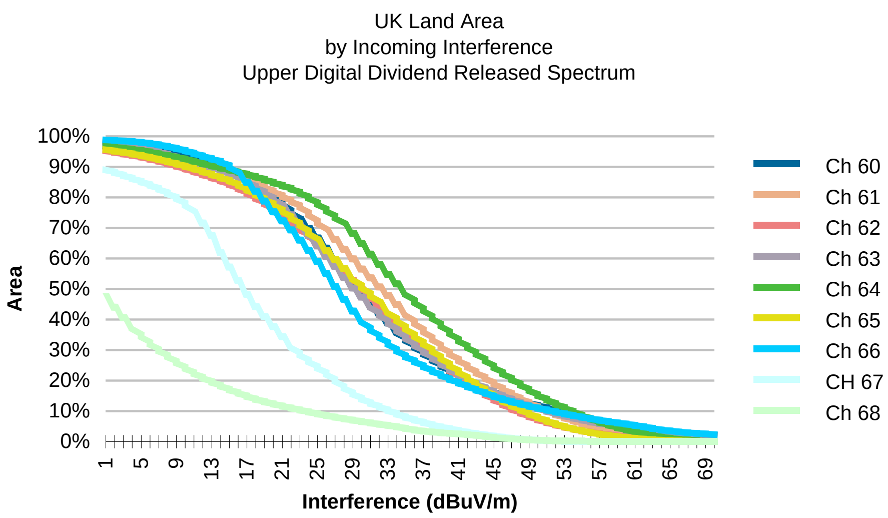

Figure 7.7: Area affected by incoming interference – Channels 60–68 [Source: Analysys Mason, 2007]

It should be stressed that results for other Member States are likely to differ considerably from the above results for the UK. In smaller Member States with a number of land borders, such as Luxembourg, it is possible that the entire country will be affected by incoming interference from DTT systems in neighbouring countries.

As part of the work undertaken by CEPT, examples have been given of options to rearrange assignments within the 470–862MHz band in order to release the 790–862MHz sub-band for uses other than DTT (by moving planned DTT use from 790–862MHz to 470–790MHz). This requires the addition of new allotments or assignments to the GE-06 plan, and negotiating their use with neighbouring countries.

7.3.2 The impact of the GE-06 permitted emission levels on potential new uses of 470–862MHz

The level of acceptable interference varies between different possible uses of the digital dividend. This depends on factors such as the technical characteristics of the receiver, the type of propagation path and receiver height.

As discussed in Section 7.2, ECC TG4 is has been tasked with developing guidelines on cross-border coordination issues between wireless broadband services in one country and broadcasting services in another. This work, amongst other things, will ensure appropriate interference thresholds (field strength trigger values) are available for use by Member States when planning for the introduction of wireless broadband services. It will also describe other basic parameters for coordination. The field strength values reproduced below are those from ECC TG4.

These trigger field strength values for wireless broadband and DTT, adjusted to a common height of 10 metres (the height of a receiving antenna specified in GE-06), give the interference thresholds in Figure 7.8 below.[116]

Service	*Coordination trigger field strength*[117]
DTT receivers	25dBµV/m/8MHz at the border
Wireless broadband terminals (mobile stations)	49.2dBµV/m/8MHz (NB) with a height loss correction factor of 18dB
Wireless broadband base stations	11.6 BµV/m/8MHz (NA) 8.2dBµV/m/8MHz (NB)

Figure 7.8: Proposed coordination trigger field strengths [Source: CEPT]

Figure 7.8 above illustrates that wireless broadband base stations (i.e. the FDD uplink, or TDD) are more susceptible to incoming co-channel interference from DTT networks operating in bordering countries than either wireless broadband terminals (i.e. the FDD downlink) or DTT receivers. Wireless broadband base stations are the most susceptible because of the sensitivity of wireless broadband receivers, as well as the typical height of the base stations relative to DTT transmission. In practice this will mean that interference from DTT transmission in one country will affect wireless broadband base stations over a greater area in neighbouring countries than either wireless broadband base stations or DTT receivers.

116 TG4(08)235 - Annex 3 – Working document towards draft report on Deliverable A – Guidelines on cross-border coordination issues between mobile services in one country and broadcast services in another.

117 NA and NB refer to codes in the GE-06 Agreement relating to systems with characteristics similar to a wireless broadband/mobile service.

In the case of the UK, and assuming a threshold for a wireless broadband system of between 8 and 11dBμV/m, more than 80% of the UK's land area will receive DTT signals exceeding this value. In comparison, a DTT network operating in the UK would be affected by incoming DTT interference from neighbouring countries within about 30% of the UK land area. The exact area affected will depend on the particular channel used. This result does not imply that 80% of the UK land area cannot be used for wireless broadband, but does suggest that coordination and/or interference mitigation will be required.

The technical characteristics of wireless broadband base stations, and the types of service offered, make this use the most sensitive use to incoming DTT interference. Other possible uses of the digital dividend are likely to be less affected by incoming DTT interference.

- For SAB/SAP, additional isolation is offered as a result of the service characteristics of that use (notably the fact that many systems operate indoors). Therefore, the size of the area in which SAB/SAP receivers will need to be protected from incoming DTT interference from neighbouring countries will be much less than for wireless broadband.

- A similar argument applies to licence-exempt uses and potentially to cognitive technologies, if these devices are operating indoors, meaning they will be less susceptible to interference from neighbouring, outdoor, DTT transmissions However, signal characteristics and deployment characteristics for actual cognitive technologies are unknown at this stage, and it is possible that some systems may be used outdoors.

- The characteristics of broadcast mobile TV are similar to DTT, and therefore will require a similar coordination area to DTT. Again, this will be less than that required for wireless broadband.

7.3.3 Steps to mitigate interference from DTT networks to wireless broadband

As demonstrated above, interference from DTT networks in one country may affect wireless broadband base receivers in large areas of neighbouring countries. There are methods that could mitigate this affect, which fall into two main categories:

- mitigation steps that can be taken by the wireless broadband network experiencing interference
- mitigation steps that can be taken by the interfering DTT network.

Each of these is discussed below.

Mitigation steps that can be taken by the wireless broadband networks experiencing interference

Antenna down-tilting and sectorisation is the most widely used form of mitigation used in wireless broadband systems to facilitate frequency coordination in border areas. This approach can be applied reasonably easily by radio planners at the network planning stage of a mobile network deployment. Since down-tilting an antenna or switching off affected sectors reduces the resulting cell range, this needs to be taken into account during planning to ensure that contiguous coverage is achieved. Additional deployment costs are therefore incurred by the wireless broadband operator when using down-tilting, in order to compensate for the coverage loss by deploying extra in-fill base stations.

Other interference mitigation techniques within a mobile network are discussed extensively within ECC TG4 Report B. These include:

- the use of adaptive antennas which can cancel incoming interference contributions
- the use of polarisation diversity
- the use of techniques such as orthogonal frequency-division multiple access (OFDMA) which can vary the interference immunity on individual sub-carriers to assist in providing interference protection

In practice, the most effective method of mitigation will depend on the technical characteristics of the wireless broadband system. Use of OFDMA, for example, is relevant to the deployment of WiMAX technologies and LTE and may benefit coordination in border areas, as a result of in-built technology features, such as fractional frequency re-use. In comparison, frequency re-use is not a feature of for current 3G networks using WCDMA technology. Using downlink power control is typical in WCDMA systems (and for instance power can be increased towards affected areas of a cell suffering interference). Antenna sectoring and down-tilting are also common and in future there is likely to be a greater use made of adaptive antennas.

All of these mitigation techniques result in additional costs to the wireless operator, either through the need to deploy extra base stations, or the potential loss of coverage in some areas and the resulting impact on the operator's revenues.

Mitigation steps that can be taken by the interfering DTT network

In situations where wireless broadband systems are operating in one country, and DTT in another, it might be possible to reduce incoming interference to those systems by modifying the nature of DTT transmissions in the neighbouring country. Options for this might include lowering the transmitted power, 'notching' DTT transmitting antennas to avoid transmission in specific directions, or use of additional in-fill stations in lieu of higher-power stations. It should be noted that as long as such a DTT network is operating within its permitted emissions levels, as determined by GE-06 or other bilateral agreements, it is under no obligation to take such mitigation steps.

Implementing changes such as these will most likely require amendments to transmitter details contained within the GE-06 plan. This therefore requires the affected country to notify its neighbouring countries, via the ITU, of these changes, and to implement these changes within bilateral and multilateral agreements. This has an associated impact on DTT timescales since roll-out could be delayed while the necessary amendments to bilateral agreements are obtained.

For any substantial changes to DTT networks, consumers’ aerials may need to be replaced or re-pointed to receive re-channelled DTT multiplexes. Marketing and publicity costs to notify DTT users of the planned changes will also be incurred.

Careful consideration needs to be given to the question of who pays for the mitigation steps taken by DTT networks. The benefits may not be experienced by the parties that implement the mitigating steps, i.e. the costs of mitigation, which may enable wireless broadband to be deployed in some Member States, may be incurred by broadcasters in neighbouring Member States.

Co-channel interference between potential services other than DTT

In general, the management of co-channel interference is less of an issue between like uses, because the deployment characteristics of these systems will be similar (e.g. same power levels and site density), and therefore easier to coordinate. Managing co-channel interference is more of a problem between systems with different characteristics. The coordination process to avoid co-channel interference in border areas is also simpler if systems on both sides of the border use similar channeling arrangements (e.g. duplex bands and direction). For FDD wireless broadband systems, the same duplex spacing is required (between the uplink and the downlink). We note that, as discussed in Section 4.2.3, frequency-agile (variable duplex) equipment is likely to be developed in the future. However, current indications are that such technology will not be widely available in the short to medium term. The issue of using a common duplex spacing does not apply for TDD systems. However, for TDD systems, there are additional coordination scenarios to consider, since the mobile device and base station both transmit in the same frequency channel. This means that two TDD systems operating in neighbouring countries will exhibit four sources of interference:

- TDD base station in one country interfering with TDD base station in another
- TDD mobile in one country interfering with TDD mobile in another
- TDD base station in one country interfering with TDD mobile in another
- TDD mobile in one country interfering with TDD base station in another.

For an equivalent FDD-FDD coordination, only two sources of interference exist, since the mobiles and base stations of FDD systems transmit and receive in different frequency bands.

7.4 Geographical sharing of spectrum

The sharing of spectrum in the 470–862MHz band is widely implemented for analogue TV, which is able to co-exist effectively with SAB/SAP uses, particularly wireless microphones. This is possible mainly because of the low-power nature of SAB/SAP use. Studies within ECC TG4 relating to the best approach to ensuring the continued operation of SAB/SAP uses envisage that sharing of spectrum between DTT and SAB/SAP will be possible within interleaved spectrum within national DTT plans. This work suggests that SAB/SAP uses at a certain location will normally be able to operate in the channel immediately adjacent to DTT. This is not the case with analogue TV, where a frequency separation (guard band) is required. The implication of this is that for the same number of DTT multiplexes within a given amount of spectrum, the spectrum available for SAB/SAP will be higher when interleaving with DTT than when interleaving with analogue TV. However, this effect is counteracted in most Member States by the fact that more DTT multiplexes are planned than old analogue TV channels.

The other main application envisaged to share spectrum within DTT (or use the interleaved spectrum within national DTT plans) is cognitive radio. CEPT work suggests that the feasibility of cognitive radio sharing has not yet been conclusively demonstrated, since it is too early in the development cycle for cognitive radio technologies for precise technical parameters to be known. We understand that the RPSG is in the process of drafting a position paper related to policy aspects of cognitive radio. In the UK, Ofcom has suggested two principles could apply to cognitive radio, to enable sharing with DTT in interleaved spectrum in the 470–862MHz band.

- Devices must be able to determine with sufficient certainty that the spectrum is not in use in the vicinity (e.g. by DTT, SAB/SAP, wireless broadband, mobile TV or other uses). This might require parameters such as sensing levels to be defined.
- The device must transmit with relatively low power, such that its signal does not travel far from its location, in order to prevent interference to the primary DTT use of the band.

As mentioned, some vendors are suggesting an alternative form of cognitive technology, that makes use of a 'geo-location' database to determine which channels devices can use at a given location. In this case, Ofcom suggests that parameters such as location accuracy and the frequency of the database enquiry are important.

Ofcom has recently published a consultation document outlining a number of key questions on sharing assumptions for cognitive devices using interleaved spectrum. The key questions include protection requirements for DTT, including the assumed DTT sensitivity level, and the additional margin needed to avoid interference to DTT reception. The additional margin needed for cognitive devices to operate alongside mobile TV is also considered, particularly considering scenarios where both devices are used within the same room. There are various elements that will affect the additional margin requirement to protect DTT and mobile TV and to enable cognitive radio to detect and avoid both types of network, and we note that these may vary across different Member States (reflecting different DTT planning assumptions being employed in different Member States).

7.5 Other compatibility issues

In addition to the above interference issues, we understand that there is potential for signals in the 470–862MHz band, and in particularly wireless broadband, to interfere with cable networks, particularly with cable wiring at customer premises. This issue has come to our attention late in the course of our study, and therefore, it has not been possible to conduct a thorough evaluation of any impact. However, we note that any impact will be largely dependent on national situations regarding the roll-out and use of cable networks. Given that interference from wireless broadband transmission in one Member State is unlikely to significantly interfere with cable networks in another Member State, there does not appear to be a European dimension to this issue. Therefore, we consider that the issues should be resolved nationally, and therefore do not consider this to be a particular constraint upon exploiting the digital dividend in the EU.[118]

To supplement the technical interference work that has been considered by CEPT, we recommend that further work is undertaken to assess how widespread the issue of interference to cable networks may be in individual Member States and the costs of resolving any harmful interference problems.

7.6 Summary

There are two main types of interference that could occur: adjacent channel interference (ACI) or co-channel interference. Guard bands of varying sizes may be required between different uses of the digital dividend spectrum in order to avoid ACI. The most difficult ACI issue appears to be DTT interfering with mobile uplinks (i.e. wireless broadband base station receivers), for which a frequency separation of 16MHz is recommended. The proposed FDD band plan being developed by ECC PT1 for the sub-band 790–862MHz suggests that the mobile uplink is accommodated in the upper part of the band (with the downlink in the lower part), which provides the necessary separation. In the case of TDD, since uplinks and downlinks transmit over the same frequency channel in a TDD system, a 7MHz guard band is proposed within the draft harmonised plan being developed by ECC PT1 to prevent interference to DTT, as illustrated in Figure 5.2 above. Note that no guard band is required between like services (e.g. adjacent DTT transmissions).

SAB/SAP will normally be able to operate in a channel immediately adjacent to DTT, and broadcast mobile TV can be deployed in the 470–862MHz band using existing GE-06 allocations.

Many existing DTT receivers are susceptible to interference from transmissions that are nine 8MHz channels above the wanted signal due to the well-known 'n+9' channel issue. There are ongoing studies in various Member States to compare the performance of different DTT receivers

118 See ECCA's comments relating to the final BIPE report on "Digital switchover" in the context of the public consultation organised by the European Commission (July 2002).

regarding this issue, since it is noted that not all receiver types are susceptible to this problem to the same extent.

There are also several issues relating to co-channel interference. Use of the 470–862MHz band in a Member State is likely to be restricted due to permitted DTT transmissions in neighbouring countries. This will be the case for all channels and all Member States, although the extent will vary. Of all of the potential uses, wireless broadband, and in particular FDD uplinks and TDD systems, will be at the greatest risk of interference, affecting large areas in a Member State (in many cases the majority of the country will be affected). DTT, mobile TV, SAB/SAP and possibly cognitive radio will be affected by cross-border interference from DTT networks in much smaller areas than wireless broadband, due to the receiver sensitivity in wireless broadband systems and the number and types of base station sites deployed. Cross-border coordination is easier to handle with the deployment of OFDMA technologies (in comparison with CDMA technologies) and FDD systems, because of the less complex interference situation.

Mitigation steps are possible by both the victim wireless broadband networks and the interfering DTT networks. Both would result in increased deployment costs. However, as long as interfering DTT networks operate within their permitted emissions levels, as determined by GE-06 or other bilateral agreements, they are under no obligation to take such mitigation steps.

Management of co-channel interference between wireless broadband networks in border areas is already managed by operators and SMAs based upon well-established and understood coordination methods. For this reason, it is easier to manage interference between like systems such as wireless broadband systems of a similar type, operating in similar channel arrangements.

SAB/SAP is likely be able to operate in the channel immediately adjacent to DTT. The implication of this is that it will be easier for SAB/SAP to interleave with DTT than analogue TV. However, this effect is counteracted in most Member States by the fact that more DTT multiplexes are planned than old analogue channels.

It is unclear whether it will be practically feasible for cognitive technologies to interleave with DTT and/or broadcast mobile TV. Work on this issue continues at both technical (CEPT) and policy (RSPG) levels.

8 Policies related to the digital dividend and its potential uses

In this section we explore those policies that may influence decisions regarding the digital dividend at an EU, national or regional level. The size of and potential uses for the 470–862MHz band mean that decisions relate to many policy areas. Those areas include high-level policies such as promoting innovation and strengthening the internal market, and sector-specific policies such as rural broadband initiatives and universal service obligations for TV.

We begin with an overview of relevant Community policies, including horizontal policies, i2010 and sector-specific initiatives. We then focus on specific policy objectives under six broad headings:

- promoting growth, innovation and competition in communication services
- enhancing public value
- facilitating universal access to key services
- supporting regional policy
- deploying PPDR
- promoting a single market for equipment and services.

Member States broadly share similar objectives, however, they may still differ on their approach to tackling these objectives, not least because of the specific characteristics of their communications markets vary widely (e.g. the number of mobile operators and broadcasters, or the penetration of terrestrial TV and broadband). Each Member State also has particular geographical, regional, cultural and linguistic conditions which may influence policy priorities towards specific uses, notably relating to public value and promoting regional policy. As the Member States’ questionnaire responses reveal, many Member States have already launched domestic policy initiatives relating to the digital dividend and relevant uses, which may or may not be consistent with the goal of promoting the efficient management of the digital dividend across the EU.

8.1 Community policies

At the highest level of EU policy, any approach towards the digital dividend must realise horizontal policies, such as the completion of the internal market, competition, innovation and inclusion. Actions by the EU and individual Member States regarding allocating and assigning the digital dividend must be consistent with these policies. The leading policy strategy for the information and communication technology (ICT) sector is the i2010 policy framework, “a European Information Society for growth and employment”. It was proposed by the Commission in 2005, following the Lisbon Strategy in 2000, which agreed a strategy for creating jobs and economic growth, including the creation of a knowledge-based economy. i2010 provides the strategic framework for the ICT sector for 2005–2010, bringing together many policies, including significant aspects of spectrum management.

Themes set by the i2010 mid-term review in 2008 include the goal of a true single market, which emphasises efficient spectrum management. While spectrum management is identified as a principle policy item, it is i2010 that "ensures coherence across the Commission's information society and media policies..."[119] For instance, some uses of digital dividend spectrum relate to policies derived from i2010's aim to provide "broadband for all." The Commission's March 2006 communication on "bridging the broadband gap"[120] linked this goal to i2010; it has now moved beyond i2010 to become a part of the Community's thinking on general economic recovery.

Specific EU policy initiatives regarding spectrum management stress the need for the efficient and effective use of spectrum. These policies are contained in the Electronic Communications Regulatory Framework (also mentioned in i2010). The Framework Directive emphasises the need for SMAs to rely on a harmonised set of objectives and principles, including the allocation and assignment of frequencies.[121] The Radio Spectrum Decision, also a part of the framework and adopted on the same day as the Framework Directive, provides a structure and tools for ensuring the effective implementation of spectrum policy in the Community. This decision provides a basis for coordinating spectrum policy in order to support specific Community policies. The Commission and Member States have worked within the RSC structure to ensure harmonised availability and efficient use of radio spectrum. Pending reform of EU spectrum policy also aims to achieve greater flexibility for spectrum management and foster relevant market-based mechanisms; the digital dividend is a significant opportunity to implement those aims across the EU.

8.2 Growth, innovation and competition in communication services

Radio spectrum is a means of delivery for many downstream services, and thus contributes to economic growth. Frequencies with attractive propagation characteristics (such as the 470–862MHz band) are relatively scarce, so their allocation can have a great impact on service market structures and the scope for those services to expand and innovate. Intervention to promote the availability of spectrum for a particular use is one tool available to regulators to encourage market competition. However, such intervention potentially carries a high risk, as any action to support one use may have the unintended consequence of unduly restricting existing or potential alternative uses of the spectrum (especially new uses that may be poorly understood or not supported with effective lobbying). Both the Commission and SMAs may therefore face the difficult task of supporting growth and competition in specific industries, whilst maintaining access for innovative uses.

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119 COM(2007)0146 (30 March 2007), section 1, "i2010 - Annual Information Society Report 2007".

120 COM(2006) 129 (20 March 2006), "Bridging the broadband gap".

121 See for instance Recital 19 and Article 9 of the Framework Directive, and in particular Article 9(2), stating that Member States will "promote the harmonisation of use of radio frequencies across the Community consistent with the need to ensure effective and efficient use thereof…".

In recent years, spectrum policy (of both the EU and individual Member States) has shifted in favour of service- and technology-neutral licensing, with an emphasis on market-based mechanisms and making spectrum available to as many viable uses as possible. Previous work for the Commission by the consortium on spectrum liberalisation[122] identified the substantial benefits of SMAs facilitating market entrants to access spectrum, especially for innovative services and technologies. As stated earlier, these benefits are primarily derived from liberalisation, stimulating increased efficiency by:

- “increases in the value of services derived from a given unit of spectrum as a result of existing users making better use of spectrum, or transferring it to someone else who can do so
- increased transparency raising awareness of the true value of spectrum and market entry opportunities, and reducing barriers to entry
- new entries stimulating competition in downstream markets
- innovation benefits owing to more rapid adoption of new services and technologies, and greater opportunity for European-based innovations.”

The 470–862MHz band will arguably be an important test of the principle of spectrum liberalisation. However, in attempting to promote EU and national objectives, the Commission and SMAs may need to balance the promotion of growth, competition and innovation within established uses, with a desire to make spectrum available for new uses. For example, in relation to the two highest value uses – DTT and wireless broadband – there are strong arguments that allocating additional spectrum to each use will enhance competition and innovation, and may also contribute to broader economic growth.

In the case of DTT, extra spectrum can be used to expand the number of TV programming channels and introduce HD services. In those Member States where terrestrial TV has significant market share, this could underpin the long-term viability of the platform as an alternative to cable and satellite. Further, in Member States where terrestrial TV has until now been little used, improved TV programming channel provision may turn DTT into a viable, competing platform. Thus, even where DTT services can be replicated by alternative technologies, there may still be benefits to consumers if increased competition promotes innovation and lower prices.

For wireless broadband, a lack of available spectrum below 1GHz is inhibiting roll-out of services outside urban areas. Although most Member States are planning to liberalise the existing 900MHz band, several mobile network operators do not have spectrum in this band, so could be at a cost disadvantage. A second sub-band within the 470–862MHz band could complement the 900MHz band, potentially enabling all operators to have access to suitable low-frequency spectrum for rural roll-out. The European Economic Recovery Plan, published in November 2008 by the

122 Analysys Mason, DotEcon and Hogan & Hartson (May 2004), “Study on conditions and options in introducing secondary trading of radio spectrum in the European Community”.

Commission, identifies high-speed broadband as a priority spending area for the Commission and Member States. The Commission argues that high-speed Internet connections “promote rapid technology diffusion, which in turn creates demand for innovative products and services”. As part of this growth-promoting strategy, the Commission urges Member States to endorse its existing proposals “to free up spectrum [in the 470–862MHz band] for wireless broadband.”[123] Of course, any intervention that favours these uses would necessarily mean less spectrum for other uses.

Separately, the Commission has also called on Member States to make digital dividend spectrum available for mobile TV, and backed the adoption of DVB-H as a single EU standard for this use. The Commission’s ‘Communication on Strengthening the Internal Market for Mobile TV’, published in July 2007, argued that mobile TV will “create jobs and business opportunities for content creators, service providers and hardware manufacturers, and … bring new value-added services to citizens.”[124] Subsequently, DVB-H has not received the same level of policy attention at either the EU or national level as wireless broadband. Two reasons for this are that the consumer interest in mobile TV services is uncertain and it appears easier to accommodate DVB-H within the 470–862MHz band alongside DTT services than is the case for wireless broadband.

In principle, market mechanisms, such as auctions for primary assignments and secondary trading, could be used to determine the optimal allocation of the 470–862MHz band to different uses. As a general rule, where growth and innovation prospects are greatest or opportunities for new competitive entry are strongest, this is likely to be reflected in users’ valuation of the spectrum. Thus auctions and trading should direct spectrum to the highest value uses and users. However, where there are different uses competing for the same spectrum, an outcome based on private valuations will not necessarily be consistent with the optimal outcome based on external value, as some uses may offer disproportionate consumer and public benefits not fully reflected in their valuations.[125] In addition, rigidities related to spectrum packaging, such as the difficulties in changing spectrum between paired and unpaired use, may impede the efficient transfer of spectrum between different uses. Given the large size of this band and breadth potential uses, some level of policy intervention alongside market mechanisms, is likely to be necessary to promote growth, innovation and competition in downstream services.

8.3 Public value

Where uses are competing for similar spectrum, it is important to consider the broader value that they could generate for society, not just the incremental value for producers and consumers.

123 COM(2008) 800 final, p.16. (26 November 2008) “A European Economic Recovery Plan’, Communication from the Commission to the European Council”.

124 See: Commission opens Europe's Single Market for Mobile TV services, 18 July 2007, IP/07/1118.

125 See, for example: Oliver & Ohlbaum and DotEcon, 2008, ‘The Effects of a Market-Based Approach to Spectrum Management of UHF and the Impact on Digital terrestrial Broadcasting’, Chapter 4.

Certain uses, such as broadband and television, have been shown to provide significant benefits to broader society (public value) by contributing to a wide range of policy goals, such as promoting social cohesion or contributing to cultural identity and education. The estimated public value generated by potential uses in discussed further in Section 9.3 below.

Simple market mechanisms, such as auctions or secondary, are not designed to take account of public value or related policy priorities. If uses and users that generate high public value (relative to the private value generated from such services) are obliged to compete for spectrum in market-oriented competitions with those that generate only modest public value, the result may be too little spectrum being allocated to users or uses generating high public value. Therefore the desire to realise policy goals of generating high public value may justify intervention in spectrum management. In this context, both the European Framework Directive and the Radio Spectrum Decision explicitly recognise the rights of Member States “to pursue general interest objectives, in particular relating to content regulation and audio-visual policy”.

Concerns about public value and regional policy have previously focused primarily on TV. In Europe, there is a long tradition of governments intervening in allocation decisions, to ensure that particular types of TV content (e.g. public service broadcasting) are available and that regional constituencies are adequately served. The measurement of public value associated with broadcasting is also quite developed in some Member States. However, as we discuss in more detail in Section 9.3 below, research has also shown that high public value may be associated with other uses, such as wireless broadband or SAB/SAP.[126] For example, depending on the availability of alternative platforms in a rural area, the provision of a commercial wireless broadband service could play a significant role in supporting the take-up of online services, thus supporting public policy goals, such as promoting e-inclusion and reducing the digital divide between different groups of people.

Public value is very difficult to quantify, especially when considered at an incremental level in relation to the use of a specific spectrum band. Research previously undertaken by consortium members on behalf of Ofcom and ARCEP identified various sources of public value that may be associated, to a greater or lesser extent, with the potential uses of the digital dividend including: education, cultural exchange, social inclusion, sustainable development, regional development, healthy public services and security, competitive advantage and R&D. Most of these benefits are difficult to quantify, therefore SMAs will have to judge the public value associated with different uses based on qualitative assessments.

Potential gains from intervention in order to support public value must be considered alongside the potential cost of intervention, in particular the opportunity costs associated with the long-term exclusion of alternative uses, and the scope for realising the value using other technologies. Such judgements cannot be divorced from the European dimension.

126 DotEcon Ltd and Dr Damian Tambini (2006), “External value of candidate uses for the digital dividend spectrum”, prepared for Ofcom as part of the ‘Preparatory Study for UHF spectrum award.

8.4 Universal access to key services

A core policy objective for all governments is to promote access and inclusion for citizens to key services. Universal access is widely recognised as generating significant public value, for example through contributions to education and social inclusion. Chiefly, universal access means ensuring availability of key services at a low cost to people that might not otherwise be able to receive them, either because they live in isolated areas or are economically disadvantaged. Key services are those considered critical for citizens to participate fully in all aspects of national economic, social, cultural, and democratic life. Most Member States have long-standing universal service or universal coverage commitments for radio, TV and fixed line telephony.

Recently, in the EU context, universal service commitments for telephony have been subsumed within a wider commitment to provide a minimum set of electronic communications services. Under the 2002 EC Universal Service Directive[127], national governments are committed to periodically reviewing what services should be subject to regulation to ensure universality. It is therefore relevant to consider whether any of the potential uses for the 470–862MHz band fulfil (or may in the future fulfil) the requirements for universal service; and also whether 470–862MHz spectrum is necessary to meet these requirements. If so, this may provide a policy justification for reserving spectrum for particular uses. There are three potential uses that could meet the requirements for universal services: TV, mobile telephony and wireless broadband. We discuss each in turn below.

TV

TV is the leading means of distributing visual media (including news, culture and entertainment) across most of the world, and as such is considered a vital service for all EU citizens. It may reasonably be assumed that it will remain a vital service for the foreseeable future, although its pre-eminent status is being eroded by the growth of the Internet as an alternative distribution platform for visual content. It is widely recognised that extending access to TV to previously excluded groups can directly release public value and also creates positive network externalities, for example by promoting education, cultural awareness and social cohesion.

Terrestrial TV has traditionally been one of the most important platforms across the EU for fulfilling universal coverage obligations. Its importance varies greatly between Member States, depending on the availability of alternative TV platforms (cable, satellite and IPTV). However, even in those Member States where terrestrial TV penetration is low, it often plays a significant role in promoting access and inclusion, owing to its universal availability and relatively low cost for consumers. In many Member States, cable is limited to urban areas, and even in highly cabled Member States, there are unserved areas. Therefore, satellite and/or digital terrestrial TV are

[127] EP and Council Directive 2002/22/EC on universal service and users' rights relating to electronic communications networks and services.

required to provide a universal footprint. In the most cabled Member States, it may be less costly to ensure universal provision via a subsidised satellite solution. However, satellite provision may be inadequate owing to planning restrictions on the installation of dishes and/or problems with reception in multi-dwelling units where a dish cannot be orientated in the correct position to receive the signal.

In summary, in most Member States, a strong case can be made for preserving terrestrial TV for the foreseeable future on the grounds of access and inclusion. However, it is much less clear what number and type of TV programming channels and technology provision is necessary to sustain DTT. Historically, terrestrial TV has endured in many Member States, despite offering relatively few (typically up to five) analogue TV programming channels.

Many broadcasters argue that without sufficient spectrum to offer a wide range of digital channels, including HD content, the terrestrial platform and its remaining viewers may become marginalised. Public service broadcasters often support this argument, as they tend to enjoy a much higher audience share on terrestrial platforms than they do on cable and satellite, where there is more competitive content and their TV programming channels may be less favoured by platform providers. Nevertheless, where public service provision is promoted through government policy on the grounds of public benefit, there may be a good case to support a terrestrial platform, if the promotion of this platform encourages greater viewing of public service content.

Mobile telephony

Unlike TV, both mobile telephony and broadband are considered under the EC Universal Service Directive on electronic communications, although neither service currently qualifies for universal service status. The Directive defines a universal service as "a minimum set of electronic communications services available to all end-users upon reasonable request at an affordable price and specified quality, independently of geographical location within a Member State." It also establishes certain considerations the Commission must take in account when deciding whether a service should be included in the scope, namely:

- "a minority of consumers would be excluded from society by the lack of availability or nonuse of specific services that are both available to and used by the majority"
- "inclusion of these services within the scope would convey a general net benefit to all consumers in cases where they are not provided to the public under normal commercial circumstances."

In the context of its second periodic review of universal services under the Directive in 2008, the Commission investigated both mobile telephony and broadband services, and concluded that *neither* currently qualifies for universal service status.[128] In relation to mobile telephony, the Commission concluded that “the competitive provision of mobile communications in the EU has resulted in consumers already having widespread affordable access to mobile communications.”

There is no reason to suppose that this situation will change in the foreseeable future. Furthermore, it appears difficult to develop a universal service argument for setting aside digital dividend spectrum for mobile telephony, given that such obligations are not required with today’s spectrum allocations.

Wireless broadband

The situation in relation to broadband is more ambiguous. Broadband failed to meet the criteria for inclusion in the recent review because it is not yet used by a majority of EU households, despite being *available* to approximately 90% of the population. However, broadband is already used by a majority of citizens in many Member States and will be used by an even greater majority of EU citizens by the time of the next periodic review. Furthermore, the Commission has noted that narrowband Internet access – which is currently identified as a universal service – will “in a relatively short horizon of time … no longer answer the requirement of being ‘sufficient to permit functional Internet access’.” For this reason, “broadband for all” is a primary objective within i2010 to accelerate the roll-out of advanced broadband communications and create an open and competitive single market for information society and media services within the EU.

In the meantime, many national governments are already developing their own plans to promote universal access to broadband services. For example, in Denmark, which is already one of the world leaders in broadband take-up, the government has set up a Højhastighedskomiteen (high-speed committee) to review nationwide broadband provision and make recommendations for expanding the availability and quality of provision.[129] In its recent report ‘Digital Britain’[130], the UK Government outlined a universal service broadband commitment of 2Mbit/s for all households by 2012.

For SMAs considering the allocation of the digital dividend, the key questions are what role, if any, the 470–862MHz band might play in promoting access to broadband, and whether intervention is necessary to support this. Put differently, each SMA must investigate whether high-speed broadband coverage could be best achieved using other technologies, such as fixed lines, or by using adequate, affordable provision of wireless broadband services could be achieved through the market. The answers to these questions may vary across Member States.

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128 COM(2008) 572 (25 September 2008), “Communication … on the second periodic review of the scope for universal service in electronic communications networks and services in accordance with article 15 of Directive 2002/22/EC”.

129 See Højhastighedskomite klar til ideudvikling (March 2009).

130 UK Department for Business Innovation and Skills and UK Department for Culture, Media and Sport (June 2009), “Digital Britain: The Final Report”.

In many Member States, fixed broadband networks (primarily DSL and cable) already reach most of the population. The EU average coverage is about 90% and in some Member States the figure is close to 100%. However, this success masks great variation in the broadband speeds available to end users. While many urban users enjoy speeds of 8Mbit/s or more, many rural users receive speeds well below 1Mbit/s, with little immediate prospect of a significant upgrade. The speed users receive may be due to the limitations of DSL technologies, where there are long distances between end users and their local exchanges.

Further, in some Member States, it would be particularly expensive to reach the last approximately 5% of the population using fixed-line technology, due to the geographically large, sparsely populated rural areas currently unserved. Both in terms of offering higher speeds in rural areas and reaching the remote areas, wireless systems may be the most cost-efficient alternative to DSL. In Germany, the Ministry of Economic Affairs recently published a national strategy on broadband that envisages using digital dividend spectrum for "…eine schnelle und witschaftliche Grundversorgung von duenn besiedelten Regionen mit Breitbandzugaengen …[fast and economical provision of broadband access to rural areas]".[131]

8.5 Regional policy

In addition to general concerns about public value and universal service, provision of communication services may also be used as a tool for promoting regional policy. With regional policy, there are often close links between promoting regional economic and social development and broader political aspirations for social justice and cohesion in society, and the preservation of regional culture and identity. The digital dividend provides an opportunity to expand the provision of regional and local communication services.

The most prominent example of intervention in spectrum to support regional policy is in TV. Historically, in many Member States, the 470–862MHz band has been reserved for provision of regional TV channels and content that might not be provided on a purely economic basis. The digital dividend spectrum could, in principle, support a significant expansion of local and regional TV. For example, Spain has announced plans for the extensive provision of regional DTT services, on the grounds of realising public value at the regional level. Meanwhile, the UK recently auctioned interleaved spectrum in the 470–862MHz band suitable for local TV services in the two regions (Manchester and Cardiff) and is reviewing the potential release of spectrum in other localities.

In principle, dividend spectrum could also be used to support regional provision of other uses. For example wireless broadband could be used to support regional broadband initiatives (either as an alternative or complement to other technologies, such as fibre). This might be justified on the basis

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131 Bundesminiterium fur Wirtschaft und Techologie (BMWI), p14. (February 2009), "Breitbandstrategie der Bundesregierung".

of both EU and national policy initiatives to create economic growth in less developed regions of the EU and integrate these economies into a single market.

As ever, the case for intervention in spectrum allocation to support regional policy must be subject to a broader review that compares the incremental benefits from promoting regional services with the potential cost of intervention, in particular the opportunity costs associated with the long-term exclusion of alternative uses. In practice, it may be that much of the value of local provision could be achieved using alternative delivery technologies. For example, in the case of TV, it may be possible to deliver regional/local TV content using broadband Internet access (either fixed or wireless) or by accommodating a modest amount of regional content alongside national content on DTT multiplexes using MFN topologies.

In summary, it is important that decisions about the provision of regional services consider the incremental value of such services and are not taken in isolation from broader considerations about the value (both public and private) created by alternative uses. Otherwise, there is a strong risk of inefficient over-provision of regional services relative to the value that could be generated from other uses of the spectrum. These concerns are most likely to apply in the case that nationwide frequency channels within the 470–862MHz band are dedicated to local/regional TV.

8.6 Policies regarding public protection and disaster relief (PPDR) services

Unlike the other potential uses, PPDR is a purely public service with no commercial role. It therefore raises policy issues that are distinct from the other potential uses. PPDR is widely perceived as a high-value use of spectrum. As discussed further in Section 9 below, the value of this use cannot be expressed solely in economic terms, as PPDR systems are used for safety of life and are regarded as necessary government services.

The use of spectrum for PPDR is typically decided at a national level. Nevertheless, numerous decisions have been adopted through CEPT processes to try to harmonise the approach to PPDR. In 1996, CEPT decisions produced a harmonised allocation of PPDR spectrum.[132] This resulted in the adoption of Europe-wide PPDR communications systems – using either TETRA or TETRAPOL.

In its 2008 Communication on "Reinforcing the Union's Disaster Response Capacity" [133], the Commission stated that "European citizens expect the Union to protect their lives and assets inside

[132] See generally RPSG draft opinion, RSPG09-258 (26 January 2009), "Best Practices Regarding The Use Of Spectrum By Some Public Sectors". The RSPG identifies public sector spectrum use as a national matter, but also references numerous CEPT decisions seeking to harmonise spectrum applications, starting from the Decision ERC/DEC/(96)01 that designated the frequency bands 380–385MHz and 390–395MHz to be used by Digital Land Systems and Decision ERC/DEC/(96)04 CEPT on specific frequency bands for the introduction of Trans European Trunked Radio System (TETRA). The latter was replaced by ECC Decision ECC/DEC/(08)05 on the harmonisation of frequency bands for the implementation of digital PPDR radio applications in bands within the 380–470MHz range.

[133] COM(2008)130 (5 March 2008), "On Reinforcing the Union's Disaster Response Capacity".

the EU" and stated that the "challenge of disaster prevention, mitigation and response…require[s] a comprehensive approach by the EU to the continuum of disaster risk assessment, forecast, prevention, preparedness and mitigation (pre- and post-disaster), bringing together the different policies, instruments and services available to the Community and Member States working as a team".

In the Communication, the Commission linked spectrum considerations to the EU's disaster response capacity. It stated that "the enhancement of broadband and mobile communications for public protection and disaster relief services, as well as the opportunity to enable EU wide interoperability, should … be examined", and in its Action Plan the Commission noted it will "consider reserving bandwidth for communicating in emergency situations".

However, the Communication is a high-level paper regarding many aspects of disaster response. It only briefly touches on the issue of spectrum availability for PPDR. It does not specifically consider the need for wireless broadband communications, or the need for digital dividend or other low-frequency spectrum to deliver such services. Furthermore, to our knowledge, the Commission has not finalised a policy on reserving bandwidth for emergency communications. Therefore, there appears to be no clear EU policy for the use of the digital dividend for PPDR.

It is also unclear how much spectrum is required for PPDR and where it should be located. How agencies using the spectrum would coordinate is not also clear, however, this is more a matter of public administration and organisation rather than spectrum management.

It was noted in the Stakeholders' Hearings and in supplementary materials provided by stakeholders, that making spectrum available in anticipation of PPDR applications is sometimes resisted by commercial operators, and thus is not an approach on which the PPDR spectrum users can rely. It is likely that a response to that issue could be made under the overall Electronic Communications Framework, in particular the Universal Service Directive Article 23 provisions for network integrity, rather than being solely a matter of spectrum management. Whether allocations for PPDR should be exclusive or shared will depend on the organisational structures the users devise; again this is not exclusively a spectrum management decision.

In the case that it is decided that an EU-wide PPDR system is appropriate, a further question to consider is whether the 470–862MHz band is the most appropriate band for deployment. There may be other less commercially valuable bands – for example, the spectrum around 450MHz has been mentioned as a possibility, which may carry a lower opportunity cost in terms of displacing other valuable uses.

8.7 Promoting the single market for equipment and services

For an operator intending to offer a mass-market service, the availability of cost-effective equipment is crucial when determining the business case for deployment in a particular spectrum band. To be cost-effective, equipment requires economies of scale in manufacturing. Often, national markets, by themselves, are not sufficiently large to provide adequate economies of scale, hence coordination between Member States is desirable in order to make cost-effective equipment viable.

There is also scope for developing communication and media services that can be used across the EU. For example, in order to facilitate roaming (mobile telephony or wireless broadband), it is important that operators deploy common technologies in the same frequency bands. While multi-mode, multi-band user equipment can be developed for some services, this is typically more expensive and takes longer to come to market. Therefore, there are potentially significant benefits from coordinating spectrum use at the EU level to realise a single market for communication equipment and services.

The opportunities offered by economies of scale and roaming provide a basis for action at the EU level to coordinate spectrum availability for certain uses. Members States share a common policy goal to promote economic growth and development across all Member States, and avoid uncertainty over the availability of spectrum across countries that might contribute to market failure. Indeed, under EU rules, SMAs have a responsibility to consider the European dimension to their spectrum award process, as well as national priorities; for example under the general requirements of Articles 7(2) and 8(3) of the Electronic Communications Framework Directive and specifically under Article 9(2) of that Directive with respect to spectrum decisions.

Of course, this is not a purely EU issue, as economies of scale and roaming opportunities may also be determined by decisions on spectrum use in other large countries and regions. Nevertheless, in general, Member States together should normally have sufficient size to realise such benefits, and many other countries and regions may be willing to adopt the same harmonised approach as the EU. The dependence on European economies of scale and roaming varies greatly for the potential uses of the 470–862MHz band. We discuss each use in turn below.

DTT

Existing DTT technology used across the EU is already designed to tune across the whole of the 470–862MHz band, although many users have narrowband aerials, which have a more limited reception range. Economies of scale for equipment is important given the mass-market profile of DTT, if to a lesser extent that mobile services (see below).

It is apparent from our review of approaches taken by Member States that there is very little certainty over the Member States' migration plans to advanced broadcasting technologies such as MPEG-4 and DVB-T2. This raises concerns about the DTT equipment market. A single European market would lead to lower equipment costs, particularly for DTT receivers and transmission equipment. However, manufacturers may have little confidence that a sufficient number of Member States will adopt these advanced technologies to generate viable economies of scale. Therefore, manufacturers may be reluctant to ensure that new DTT receivers incorporate the latest/most spectrally efficient technologies. This, in turn, may mean that the price of equipment incorporating new technologies (particularly consumer DTT reception equipment, including set-top boxes and in-built DTT receivers in televisions) does not fall as rapidly as it might otherwise. This would make it more difficult for Member States to make the transition to new technologies, due to concerns about consumer upgrade costs.

As DTT is primarily aimed at fixed rather than mobile TV sets, roaming is not an issue.

Broadcast mobile TV

It is likely that the majority of broadcast mobile TV receivers will be integrated with cellular phones or wireless broadband devices. The realisation of economies of scale for such devices is crucial to the viability of this use. Therefore, it is important that devices are common across a significant number of Member States, or that economies of scale are achieved by using devices common to other large markets (e.g. the USA).

Devices incorporating broadcast mobile TV technologies (such as DVB-H, which has been backed by the Commission and has been deployed in a number of Member States, e.g. Finland, Germany and Italy), tune over large portions of the 470–862MHz band. The notable exception is devices integrated with GSM (and potentially in the future other technologies such as UMTS and LTE), where frequencies below 750MHz are preferred. The preference is to prevent interference between GSM (or potentially UMTS and LTE) and broadcast mobile TV in the 750–862MHz range. Therefore, it is not necessary for countries to use exactly the same frequencies in order for a common device to be used. Indeed 14 Member States either have deployed or are planning to deploy broadcast mobile TV networks using frequencies assigned to multiplexes at GE-06.[134] By their nature, these multiplex assignments cover a range of frequencies across the 470–862MHz band, though frequencies are likely to be chosen below 750MHz.

In order for economies of scale to be achieved it is important that a common frequency range is used by Member States; this range could cover a large portion of the 470–750MHz range. There is a trade-off between the size of the tuning range for broadcast mobile TV and device costs. A large tuning range means that larger or more costly components are required within the device.

It may also be possible to take advantage of economies of scale by sharing common frequencies with substantial non-EU markets. Again it is not critical that exactly the same frequencies are used as in these other markets, what matters is whether the allocated frequencies are within the tuning range of standard equipment in those markets. However, the opportunity for such an approach is limited, as the frequencies/technologies used in other countries are not compatible with the 470–862MHz band in Europe.

[134] Source: responses to Member States’ questionnaires (January 2009)

The benefit generate from roaming appears significantly lower than for uses such as wireless broadband. TV content is generally aimed at domestic markets, and there are often language barriers to watching TV abroad. However, if mobile TV services become successful, there may be benefits from roaming between Member States that use common languages (e.g. France and Belgium, Germany and Austria, or the UK and Ireland), as well as from consumers wishing to watch content in languages other than their own native language.

Wireless broadband (FDD systems)

For wireless broadband, international economies of scale in equipment production are essential for the viability of spectrum use. Both devices and network equipment are tailored for specific frequency ranges and duplex spacing. The global, mass-market nature of this industry means that operators depend on being able to persuade manufacturers to provide them with a wide range of low-cost handsets. In turn, this requires most countries (especially smaller ones) to adopt the same frequency bands for wireless broadband.

During the Stakeholders’ Hearings, an equipment manufacturer stated that if a market the size of Europe were to conform to one band plan for the digital dividend, then the bill of materials for the radio frequency components of a wireless broadband device would be USD0.80 per device. If there were three different band plans, this would rise to USD3.80.

In view of the potential economies of scale, following WRC-07, considerable momentum has built up within Europe for adopting a sub-band within 790–862MHz to support uses such as wireless broadband that require paired frequencies. However, as discussed in Section 6.3, Member States vary in their current plans for the adoption of the sub-band: some Member States have specific plans to make the sub-band available; others are considering making one available; many Member States are currently undecided; and one Member State plan to use all of the 470–862MHz band for DTT.

It is possible that some Member States may wish to make additional frequencies available for uses requiring paired spectrum (including wireless broadband). Indeed, some industry participants to the Stakeholders’ Hearings argued that the 790–862MHz sub-band should be viewed as a ‘starting point’. The current dependence on pre-defined duplex spacing means that the decision to allocate a band for an FDD system is usually a one-off decision, therefore, it will not be possible to enlarge the 790–862MHz sub-band at a later date without changing all the equipment. This suggests that coordinating the adoption of further sub-bands at frequencies below 790MHz should be considered, with the objective of ensuring that if Member States wish to make additional spectrum available, this spectrum also benefits from wider economies of scale and cross-border roaming (i.e. individual Member States do not create their own ‘islands’ of additional spectrum for wireless broadband services in isolation of each other).

Again, it may be possible to take advantage of economies of scale by sharing common frequencies with other substantial non-EU markets. As discussed in Section 6.5.2 above, it may be possible for Member States to align with band plans in the USA, Japan or South Korea. In particular Member States wishing to adopt further sub-bands below the 790–862MHz sub-band could align with the 700MHz band plan in the USA (698–716MHz paired with 728–746MHz, or 746–760MHz paired with 776–790MHz), or with 710–770MHz in Japan.

For mobile operators, international roaming is also an important source of value for users and revenues for operators. Increasingly, users expect to be able to have access to wireless broadband as well as voice when they travel abroad; indeed, most European travellers now take it for granted that their phones will work anywhere in Europe. Developing and manufacturing handsets that can roam over multiple frequency bands is more costly, especially given the space and power limitations of mobile handsets, hence there are substantial benefits to be gained from operators in different Member States using the same frequencies to roll out particular technologies.

Wireless broadband (TDD systems)

As TDD systems operate in unpaired spectrum, they are inherently more flexible than FDD systems over their location within a frequency band. This means that it is rather less important that Member States adopt the same frequencies within the 470–862MHz band for TDD technology. Nevertheless, wireless broadband using TDD will need to compete with similar services using FDD technology, so economies of scale will be important. Indeed, the scope for economies of scale may determine whether it is viable to integrate TDD into mobile handsets that are targeted at the mobile telephony market, as well as wireless broadband. If economies of scale are limited, TDD may only be viable as a competitor in the data card market, connecting portable or fixed devices, such as laptops, to the Internet.

To date, TDD systems have been launched only in a few countries and areas, so international roaming has not been a primary concern. However, in order for TDD to become a viable competitor to FDD systems in the wireless broadband market, the ability to roam may be important. This will only be possible if services are rolled out in the same frequency band.

In summary, the economies of scale and roaming benefits for TDD systems are potentially as large as those for FDD systems. However, as TDD technology uses unpaired spectrum, frequency allocations can be more flexible within the 470–862MHz band.

Wireless broadband for public protection and disaster relief (PPDR)

Economies of scales are important for PPDR systems, particularly for bespoke networks that meet the specific needs of PPDR (e.g. resilience). At the Stakeholders' Hearings, one stakeholder stated that economies of scale significantly reduce costs of deploying such networks. An example was provided indicating that economies of scale could lower the cost of device units from EUR2000 to

EUR500. Economies of scale would also reduce network equipment costs. It is questionable whether any Member State would commission a bespoke PPDR network in isolation.

However, it may be possible for PPDR systems to be delivered using wireless broadband technologies used by other commercial organisations (e.g. UMTS, WiMAX), as highlighted by WIK Consult in its report “Safety First Reinvesting the Digital Dividend in Safeguarding Citizens”[135] However, WIK Consult concluded that dedicated networks are preferable as commercial technologies are optimised for different objectives than PPDR, namely meeting consumer experience, service and price demands; and these networks are not designed to cater to the stringent requirements of PPDR organisations. If such a commercial network could be used for PPDR, this would immediately provide economies of scale. There are over 200 UMTS networks in operation worldwide, and over 300 million subscribers.

WIK Consult also highlighted the need for roaming and interoperability between Member States, stating that:

“[the] increasing globalization of terrorism and other security threats makes it important to ensure that future PSS [public safety services, PPDR] systems are capable of working across national borders. Neighbouring countries’ networks must interoperate with one another for both routine day-to-day operations and disaster relief.”

Services ancillary to broadcasting and programme making (SAB/SAP)

The availability of spectrum for SAB/SAP varies across Member States. In some Member States certain frequencies within the 470–862MHz band are dedicated nationwide for SAB/SAP use (seven Member States indicated that this was the case in the questionnaire responses). In Member States that do *not* have a dedicated frequencies, SAB/SAP typically uses interleaved spectrum throughout the band.

Given the varied nature of SAB/SAP users, it is important to consider each category of user individually when considering the benefits from a single EU market:

Background social use — Although there are a large number of users, the demand from each is low, typically only using a small number of wireless microphones and IEMs.

In those Member States that have dedicated nationwide frequencies for SAB/SAP, the vast majority of equipment used by this category is designed to operate these frequencies. These users typically have little technical knowledge: they are unlikely to know which frequencies are available for SAB/SAP at each location and how to tune equipment to these frequencies.

135 See footnote 104.

Therefore, there is a significant benefit from having dedicated frequencies to which new equipment can be tuned. This limits the likelihood that users tune into frequencies that are not available for SAB/SAP, causing interference to other uses. This category of user has little need to use their equipment in other Member States, therefore roaming is of negligible benefit.

Background commercial use

Again demand from users in this category is generally low, typically only using a small amount of equipment that can operate within just one 8MHz channel.

The value of dedicated nationwide frequencies is less clear for this category. Some users have little technical knowledge and therefore benefit from the simplicity of using dedicated frequencies. Others find the risk of receiving interference from other users in the dedicated nationwide frequencies too high. Therefore, they prefer the less used interleaved channels.

Roaming is of little benefit for this category of user.

Larger-scale use within fixed sites

These are high-value, commercial users that need more equipment than can fit into one 8MHz spectrum channel. Some users, such as large commercial theatres, require a very large number of wireless microphones and IEMs (potentially more than 50).

This category of user is typically more technically knowledgeable than background users. In order to gain access to sufficient spectrum for their needs, they need to know which frequencies they are permitted to use at their location. They then need to source the appropriate equipment. Also many users view the risk of interference from other users in the dedicated nationwide frequencies as too high. Therefore, users in this category have relatively little value for dedicated national frequencies. As some users in this category require access to a large number of potential spectrum channels, they may suffer if the amount of interleaved spectrum were to significantly reduce.

Given that these users are located at fixed sites, roaming is of negligible benefit.

Special events

This category includes large, one-off, short-term events. These can have very large spectrum needs (such as major pop concerts).

These users are typically even more technically knowledgeable than the above category. This is because the location of such special event varies, meaning that the spectrum that is available for SAB/SAP also varies for

	each event. Therefore, although there is a risk of interference when using dedicated nationwide frequencies, there is also a benefit as the same equipment can be used nationwide using these frequencies. As users in this category have the highest demand for spectrum channels, they would suffer the most if the amount of interleaved spectrum were to significantly reduce. It is possible that the SAB/SAP provision for major special events could be sourced internationally. Therefore, there may be some benefit from users being able to roam.
Tours	This category involves the use of spectrum by a touring company operating from multiple sites in succession. These users benefit significantly from the availability of dedicated nationwide frequencies. This means that touring companies do not need to either retune their equipment when arriving at a new location (if this is possible given the limited tuning range of equipment) or they need to own and operate more than one set of equipment. Touring shows may operate across national boundaries, particularly across Member States that share common languages. Therefore, the may be some benefit from users being able to roam.

In Member States that have dedicated nationwide frequencies, the majority of SAB/SAP equipment sold is designed to operate in these nationally available frequencies. Indeed, in the UK almost all of the basic, high-volume equipment used by background users (both social and commercial) and touring companies tunes across Channel 69 – the nationally available channel. However, the nationally available frequencies vary between Member States. For example, Channel 63 is used in the Netherlands, whilst Channel 69 is used in Ireland, Malta and the UK.

Wireless microphones and IEMs can typically tune across just a few 8MHz spectrum channels. We understand that basic equipment, often used in the nationally available channels, typically tunes over only two 8MHz spectrum channels. As in most Member States, use is spread across the band and Member States with dedicated channels vary in their frequency location, therefore usage across the EU does not focus on any specific channels. As a result, full economies of scale may not be being realised.

If the choice of dedicated nationally available channels was consistent, or fell within a common two or three spectrum channels, those Member States that chose these dedicated channels would benefit from increased economies of scale. In particular background users and touring companies operating equipment in those Member States would benefit. However, given that existing business practice suggests that it is viable to build equipment given the current usage patterns, and given the relatively small volumes of equipment sold each year (at least when compared to mass market uses such as wireless broadband), the total benefits from such economies of scale may be relatively small compared to mass-market uses.

It should also be noted that these nationally available frequencies are generally located in the 790–862MHz sub-band. Therefore, if Member States wish to make the 790–862MHz sub-band available for other uses (e.g. wireless broadband), they may need to relocate the nationally available SAB/SAP frequencies. This may be an opportunity for Member States to coordinate the choice of replacement frequencies. There appear to be two options:

- If the 790–862MHz sub-band is adopted with a paired band plan (e.g. for FDD wireless broadband technologies), the centre gap between the uplink and downlink channels (possibly 820–832MHz) could be used for SAB/SAP. However, SAB/SAP users have concerns regarding feasibility, owing to further concerns about interference from wireless broadband devices. Also, the distance between this centre gap and the nearest interleaved channel, Channel 60 (782–790MHz), would be 30MHz, which is greater than the tuning range of most SAB/SAP equipment using the band. Therefore, this option would not allow users that do *not* wish to use dedicated nationwide frequencies to use adjacent interleaved channels. By using these adjacent channels, users can benefit from the economies of scale generated by having dedicated nationwide frequencies, without the interference concerns of using these frequencies.

- The second option is using frequencies elsewhere in the 470–790MHz range, i.e. outside the proposed sub-band. The UK is considering dedicating Channel 38 (606–614MHz) to SAB/SAP; this channel is currently used for radio astronomy in the Netherlands, preventing medium or high-power use in large areas of the UK. However, this channel may not be available across the whole of the EU.

Cognitive technologies

Services that use cognitive technologies over digital dividend spectrum may vary widely (wireless local area networks, wireless alarms, medical applications, etc.). Therefore, the requirements for economies of scale and roaming will also vary. However, some services, such as wireless local area networks, may well become mass-market products. There may also be a benefit from roaming.

In a similar manner to TDD technologies, equipment that uses cognitive technologies is likely to tune over a range within the 470–862MHz band. Therefore, in order to achieve economies of scale and meet roaming needs, exactly the same frequencies do *not* need to be available across Member States. It should also be noted that cognitive technologies might be used in other countries, such as the USA. Therefore, economies of scale may be achieved by aligning frequencies with these countries.

Innovation reserve

Spectrum reserved for innovation is likely to be used to trial new technologies and services; economies of scale or international roaming benefits are unlikely to be relevant.

8.8 Summary

There are many aspects of public policy, at EU, national and regional levels, which may impact the approach of an SMA to allocating the digital dividend.

At the EU level, there are three main policy areas relevant to the digital dividend. Any approach to the digital dividend must firstly be consistent with horizontal policies (internal market, competition, innovation, inclusion, etc.). Secondly, there are relevant policies derived from the i2010 policy framework, the leading policy strategy for the ICT sector, such as "broadband for all". Finally, there are the spectrum management policies contained within the Electronic Communications Regulatory Framework, which aim to promote the efficient and effective use of spectrum.

Growth, innovation and competition across the EU are supported by access to spectrum, especially low frequencies with attractive propagation characteristics. Intervention by SMAs to promote the availability of this spectrum for a particular use may encourage this economic development, but a balance is needed between supporting growth and competition in specific industries (such as DTT, and wireless broadband), and maintaining access for innovative uses.

In regional policies, there are often close links between promoting regional economic, social development and the preservation of regional culture and identity. The most prominent example of intervention in spectrum to support regional policy is in TV. The digital dividend provides an opportunity to expand the provision of regional and local communication services and could support a significant expansion of local and regional TV. However, any intervention to effect this expansion should take into account the opportunity costs of excluding of other uses.

PPDR is widely perceived as a high value use of spectrum. However, there currently does not appear to be a clear EU policy for the use of the digital dividend for PPDR. Further, it is not clear where it should be located; spectrum outside the 470–862MHz band may provide lower opportunity cost options.

It is important that the public value is taken into account when comparing the benefits of different uses of the digital dividend spectrum. In principle, market mechanisms could be used to determine the optimal use of the band. However, such an approach may not take account of the public value of some uses as well as their ability to contribute to public policy goals. Note however, that it is important to consider the incremental public value from uses of the digital dividend. For example, the digital dividend spectrum is often offered as a solution for providing universal service for television and broadband. However, this is not a reason, as such, for allocating dividend spectrum to these services. The key questions are:

- could universal service be achieved using other platforms and spectrum?
- what are the benefits and costs of the alternative deployment approaches?
- and are there benefits from using digital dividend spectrum in addition to alternative delivery platforms (e.g. in order to create platform competition and increase consumer choice)?

For most potential uses, it is beneficial if the same broad frequencies are used across Member States in order to realise economies of scale, and for some services international roaming. However, for two reason this issue is of particular importance for wireless broadband: firstly, economies of scale are essential in order for equipment to be financially viable; secondly, if FDD technologies are deployed then the same frequencies for both the uplink and downlink need to be available across Member States in order to realise economies of scale and enable roaming.

At the national level, attention has typically been focused on the provision of television and broadband services. This is unsurprising given the high economic and public value attached to these services. Television is recognised as a key economic sector, a crucial source of public value and a service that should be universally available. Broadband is perceived as an enabler of economic growth and innovation. However, the focus on television and broadband raises concerns that related policy decisions may be made in isolation from one other, and from decisions on other potential uses of the 470–862MHz band. It is already apparent that in some Member States, the ability of regulators to identify larger blocks of digital dividend spectrum suitable for wireless broadband is complicated by earlier domestic decisions and multilateral accords on the deployment of DTT in the band. In order to optimise spectrum allocation, it is essential to take a holistic approach to management of the 470–862MHz band that considers the opportunity cost of denying alternative uses access to the spectrum. This is likely to involve a combination of market mechanisms and carefully considered policy interventions.

When weighing up the case for intervention to support a particular use, there is a risk that focus could be on the *overall* benefit of the potential uses rather than the *incremental* benefit, both private and external, from using digital dividend spectrum. Certain uses, such as TV and broadband, are very valuable, but a significant proportion of this value may be realised by alternative technologies, such as cable, DSL and satellite, or alternative spectrum bands. Furthermore, much of the value associated with a particular use may be realised through a critical mass of spectrum provision within the band; incremental value from using additional spectrum may be quite modest. Failure to consider the incremental value may lead to a Member State overvaluing a potential use of the digital dividend to the detriment of others.

There is a strong European dimension to decision on allocation of the 470–862MHz band. Policy decisions in one Member State necessarily have an impact on neighbours, owing to requirements for frequency coordination and the importance of economies of scale in equipment. For most potential uses, it is beneficial if the same broad frequencies are used across Member States in order to realise economies of scale. Roaming is a particular issue for wireless broadband and (possibly) mobile TV services. There are also positive effects on Member State economies through greater growth, innovation and competition from the strengthening European markets for equipment and services. Some potential uses, most notably broadband, are central to EU policy priorities, notably i2010. Thus, if Member States base their decisions on incomplete or inaccurate assessments, or take decisions in isolation from the broader EU context, there is a risk that all Member States will suffer to some extent.

9 Value of the digital dividend from potential uses

In Section 4.1 we introduced a number of potential uses of the digital dividend, which vary widely, from high-power uses such as DTT to low-power uses such as SAB/SAP. Therefore, demand for the 470–862MHz band is expected to be high, as is the value that potential uses could generate.

When assessing the value that potential uses of the digital dividend could generate it is important to consider all forms of value. Some studies have, for example, focused either on the commercial value generated by particular uses, or on the policy objectives that particular uses serve. Instead, the *total* value should be considered, consisting of both private value and external value.

- **Private value** is the direct benefit to individuals from their own consumption of a service (i.e. the value consumers place on the service), less the costs of producing the service. In economic terms, this is equal to the sum of consumer and producer surplus.

- **External value** is the additional benefit to consumers or third parties not reflected in the value of the service to consumers. This broad definition captures all types of externalities[136], including (1) **public value**, meaning the value that the public derives from services because of their broader contribution to society, such as social cohesion, universal service provision and contributions to culture and education, and (2) **other sources of value**, such as investment spill-overs (consequential benefits for other sectors of the economy) and non-internalised network effects.

The equation for total value is illustrated in Figure 9.1 below.

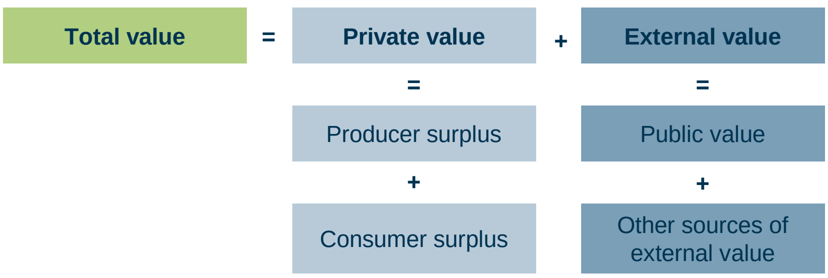

Figure 9.1: Measures of total value for the digital dividend [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

9.1 The importance of an incremental approach when valuing potential uses

When considering the total value that could be generated by the digital dividend, it is important to take an *incremental* view. For each service, what matters is the incremental value generated by that service from using spectrum in the 470–862MHz band over and above the value that would be realised if the service was only provided by alternative means. The concept of incremental value is illustrated in Figure 9.2 below. If a service can only be provided using digital dividend spectrum,

136 Externalities are the unintended effects of economic activity on third parties.

total value would include all benefits (less costs) associated with the service. However, where the service could be provided using alternative means, such as another spectrum band or via fixed networks, we are only concerned with the *incremental value* from using digital dividend spectrum.

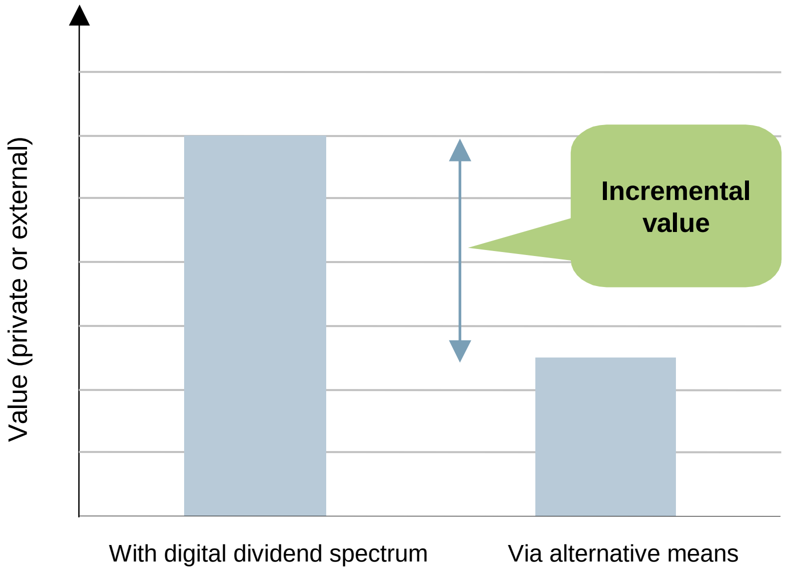

Figure 9.2: Incremental value [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

Therefore when considering the incremental value for each potential use, it is appropriate to ask a series of questions:

- Is the service already provided using other means?
- Could it be provided using a different delivery technology or spectrum band?
- Are there any differences in the cost profiles or service quality associated with provision using digital dividend spectrum instead of alternative means?
- Is there scope for competition between platforms, and could this generate any additional benefits for consumers?

The factors affecting incremental value for each use vary significantly, as described in Figure 9.3 below.

Use	*Incremental value*
DTT	Most consumers in Europe have a choice of between two and four delivery technologies for TV services: namely DTT, cable, satellite and IPTV. Of these, DTT has more constrained capacity, so typically it could be possible to replicate the entire DTT offering and provide additional services using alternative delivery technologies. This implies that any incremental value from using digital dividend spectrum for DTT is likely to be derived primarily from greater consumer choice. Regarding consumer choice, even if programming channel provision from DTT is a subset of that available on other platforms, consumers may still prefer DTT. Research conducted for Ofcom (UK) on the digital dividend suggested that

consumers place very high value – both private and public – on the core channels provided by established broadcasters, whereas the value placed on additional channels is small and diminishes rapidly[137] (potentially even to a negative value for some consumers, who find too much choice overwhelming). There are also strong legacy ties to terrestrial platforms in some Member States: consumers may prefer an aerial to a satellite dish on aesthetic grounds, and some local planning rules prohibit satellite dishes. In many Member States, consumers already have aerials installed, so this may be the cheapest available option, especially for second TV sets.

It is likely that the existence of a DTT platform would provide competition for satellite and cable providers, especially in (areas of) Member States where only one of these delivery technologies is available. Specifically, the availability of free-to-view DTT services would create an incentive for satellite providers to price their subscription services more aggressively, including offering free packages of basic channels as a lead into subscription services. It would also incentivise improvements in service quality from satellite and cable providers, including offering HDTV, innovative programming channel packaging and electronic programme guides. Competition could also reduce the importance of regulating carriage charges on cable and satellite.

Broadcast mobile TV

Broadcast mobile TV can only be delivered using radio spectrum. The 470–862MHz band is the leading candidate band, owing to its attractive frequency propagation characteristics and the scope for coordinating equipment production across Europe. For network providers, alternative bands, such as L-band (1452–1492MHz) could be used, but these are likely to involve more costly deployment than the digital dividend. The long-term viability of broadcast mobile TV, especially if deployed using higher frequency bands such as L-band, is not certain.

For consumers, broadcast mobile TV services provided will probably be similar regardless of the frequency band used, although higher frequency bands may have more restricted coverage and possibly higher subscription costs. As an alternative to a dedicated broadcast mobile TV service, consumers could rely on services streamed over wireless broadband networks. However, wireless broadband is not a particularly suitable delivery technology for streaming the same live content to many viewers due to the poorer quality service and higher prices than a dedicated delivery technology.

The incremental private value from using digital dividend spectrum for broadcast mobile TV, is either: (a) the cost savings and any consumer benefits from having a service using the 470–862MHz band instead of other frequencies; or (b) if broadcast mobile TV is not viable in other frequency bands, the additional consumer surplus for users over and above the main alternative of accessing broadcast mobile TV using wireless broadband.

Commercial wireless broadband

Wireless broadband is likely to be provided across Europe using other frequency bands, notably the 900MHz and 2.6GHz bands. The 2.6GHz band is particularly suitable for providing LTE services, as there is the potential for operators to acquire at least 2×20MHz of spectrum. However, the limited frequency propagation of this band means that coverage may be limited to urban areas. For rural areas, 900MHz spectrum provides the potential for wide-area LTE coverage. However, there is insufficient spectrum available in the 900MHz band to allow multiple operators to adopt higher bandwidth LTE profiles. The availability of this spectrum is also constrained because it is still used for GSM services.

137 See footnote 126.

	The incremental value of the 470–862MHz band primarily comes from the increased capacity for wireless broadband provision outside urban areas. Together with the 900MHz band, there may be scope for several operators to have access to large blocks of contiguous spectrum (more than 2×10MHz) at lower frequencies. The main source of incremental value is likely to be the preservation of existing competition, with at least three network operators able to offer nationwide high-speed services with similar cost bases. Rural areas may also benefit from higher speeds and faster roll-out. In particular in areas where the availability of other broadband delivery platforms is limited, commercial wireless broadband services could add significant public value by easing the urban/rural digital divide.
Wireless broadband for PPDR	Wireless broadband for PPDR (in addition to or to replace existing services) could realistically only be deployed terrestrially using spectrum below 1GHz, deployment at high frequencies would be too costly. It may be possible to deploy such a service in other bands, such as 450MHz, but less spectrum is available and it would require concerted coordination across Member States. Thus the incremental value is either (a) the additional value over and above existing national services; or (b) any extra costs or changes in service quality from using another band.
SAB/SAP	Parts of the 470–862MHz band are already extensively used for wireless microphones and other applications. In principle, these systems could be redeployed within the band or moved to other bands using similar frequencies, subject to spectrum availability. However, new equipment would be required, meaning that some amateur and professional use may be discontinued. Further, limited spectrum availability may compromise the ability of professional SAB/SAP users to deploy services at major events. Thus the incremental value of this service would appear to be the cost of replacing equipment and any loss in services.
Cognitive technologies	Cognitive technologies could be used to provide a variety of wireless communication services. Typically, these are services that are already provided using wireline or wireless systems, so would generate incremental value only to the extent that they offer reduced cost or improved service quality relative to these existing systems. Cognitive technologies could also potentially be offered using other spectrum bands, most likely at higher frequencies. When considering incremental value, the extent to which there might be other spectrum available and the potential impact of using higher frequencies on cost and availability also needs to be taken into account.
Innovation reserve	Spectrum reserved for innovation could be used to trial new wireless technologies. If an experimental technology proved successful, the absolute value created by a new technology could be very large. However, the extent to which there is incremental value from using digital dividend spectrum may depend on whether it was possible for innovators to access alternative, similar spectrum. As trials are often small scale (e.g. in terms of geographic area), it may be possible to establish innovation reserves using interleaved spectrum, in which case even if the incremental value from using digital dividend spectrum is small, this may not matter as the opportunity cost of such activity may also be low.

Figure 9.3: Sources of incremental value for potential uses [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

As evident from Figure 9.3, a prominent issue surrounding incremental value is the value attached to technology and network competition. The availability of a competing delivery technologies using digital dividend spectrum may bring significant benefits for consumers, through competitive pricing and quality of service innovation. For TV, much of the incremental value is derived from DTT competing with cable and satellite. For wireless broadband, the digital dividend potentially offers a solution to insufficient capacity in the 900MHz band, enabling several networks to offer high-speed services with competitive cost profiles and thereby generating substantial incremental value.

Research has demonstrated that there is often a close link between the take-up of new services and the extent of competition. For example, a 2005 study by Maldoom, Marsden, Sidek & Singer observed that countries with higher levels of platform/infrastructure competition in broadband provision (including DSL, local loop unbundled cable, fibre to the home and others) typically experienced keener price competition and faster take-up of broadband services.[138] On this basis it seems reasonable to assume that the presence of a viable DTT platform in a country would be likely to have a positive impact on the take-up of TV services and on the development of HDTV across all TV platforms. Similarly, if the digital dividend spectrum can play a role in sustaining the availability of multiple mobile network operators in Europe, then the long-term value created by competition may be great. The existence of such competitive pressure may also reduce or avoid the need for regulation of prices, network access and service quality, and thus also the risk of market distortion in the owing to intervention.

Quantifying benefit generated by competition is difficult, as it is likely to be highly specific to the industry. However, our consortium’s study for the Commission on benefits from trading and liberalisation[139] assumed a 15% reduction in prices as a result of a new, competitive entrant. This was based on observations from simple models of oligopoly competition, and observations of even greater price falls in European mobile markets when competition was increased from two to three or four mobile operators. However, these benefits must be set against the increased costs, including environmental costs, required for network duplication.

Below we review the results of existing studies on the value generated by services using the digital dividend spectrum. We consider private value first, then external value.

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138 Maldoom, Marsden, Sidek & Singer (2005), “Broadband in Europe: How Brussels Can Wire the Information Society”, Springer-Verlag, New York.

139 Analysys, DotEcon and Hogan & Hartson for the European Commission (May 2004), “Study on conditions and options in introducing secondary trading of radio spectrum in the European Community” , Section 15.3.3, pp. 204-207.

9.2 Estimates of the value of potential uses: private value

Private value is the direct benefit to individuals from their own consumption of a service (i.e. the value consumers place on the service), less the costs of producing that service. A number of studies, at both national and European levels, have considered the private value of potential uses of the digital dividend. We summarise the results of six major studies, for which the results are publicly available:

- Analysys Mason, DotEcon and Aegis Spectrum Engineering's study for Ofcom to prepare for the award of the digital dividend[140]
- Analysys Mason and Hogan & Hartson's digital dividend study for ARCEP on the economic benefit that could be generated from the digital dividend[141]
- Analysys Mason's digital dividend study for the Dutch Ministry of Economic Affairs on the economic and social limitations to alternative uses of digital dividend spectrum[142]
- Spectrum Value Partners' digital dividend study for Ericsson, Nokia, Orange, Telefónica and Vodafone on allocating UHF spectrum to maximise benefits for European society[143]
- Oliver & Ohlbaum and DotEcon's study for the EBU on the effects of a market-based approach to spectrum management and the impact on digital terrestrial broadcasting[144]
- SCF's study for Deutsche Telekom on alternative uses of the digital dividend.[145]

Note that the focus and objectives of each of these studies varies, therefore care must be taken when comparing their results. They were commissioned by stakeholders with different requirements and, as such, have differences in emphasis. They consider different Member States, each of which have specific characteristics that will influence the value of services using the digital dividend. Finally, they have different basic assumptions: the valuation periods, the amount of spectrum that is assumed to be available for DTT, etc. However, the results of these studies can be used to approximate the value of each potential use across the EU.

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140 Analysys Mason, DotEcon and Aegis Spectrum Engineering for Ofcom (December 2006), "Digital dividend review".

141 Analysys Mason and Hogan & Hartson for ARCEP (2008), "Valorisation du dividende numérique".

142 Analysys Mason for the Dutch Ministry of Economic Affairs (2008), "Economic and Social Limitations to Alternative Uses of 'Digital Dividend' Spectrum".

143 Spectrum Value Partners (2008), "Getting the most out of the digital dividend".

144 Oliver & Ohlbaum Associates and DotEcon for EBU (2008), "The Effects of a Market-Based Approach to Spectrum Management of UHF and the Impact on Digital Terrestrial Broadcasting".

145 SCF for Deutsche Telekom (2007), "The Mobile Provide".

Analysys Mason, DotEcon and Aegis Spectrum Engineering’s study for Ofcom

Analysys Mason/DotEcon/Aegis Spectrum Engineering conducted a study for Ofcom in 2006 as part of its “Digital Dividend Review”. The study estimated the value of potential uses of the digital dividend in the UK, including both the private and external value. A high-level summary of the results of this assessment was included in a consultation paper by Ofcom.[146] The private value results are summarised in Figure 9.4 below, the external value results are considered in the Section 9.3 below.

Use	*Main conclusions*
DTT	Using the digital dividend to deploy one additional DTT multiplex (for either SD or HD services), in addition to the six multiplexes already planned in the UK, could create between GBP0.5 billion and GBP3.5 billion of private value (discounted value over 20 years). This would require between 24MHz and 112MHz of spectrum (though this spectrum could potentially also be shared by other services, such as another DTT multiplex or SAB/SAP).
Broadcast mobile TV[147]	Using the digital dividend to create one broadcast mobile TV multiplex could create between GBP0.3 billion and GBP3 billion of private value (discounted value over 20 years). This would require between 8MHz and 48MHz of spectrum (though this spectrum could potentially also be shared by other services, such as DTT or SAB/SAP).
Wireless broadband	Using the digital dividend for wireless broadband services could create up to GBP2.5 billion of private value (discounted value over 20 years). This would require up to 56MHz of spectrum.
SAB/SAP[148]	Using a nationwide 8MHz channel plus up to 32 channels of 8MHz on an interleaved basis with DTT for SAB/SAP could create between GBP0.1 billion and GBP0.5 billion in private value[149] (discounted value over 20 years).

Figure 9.4: Private value estimates of Analysys Mason, DotEcon and Aegis Spectrum Engineering’s study for Ofcom [Source: Ofcom, 2006]

Although this was the most comprehensive study of the value generated by uses of the digital dividend at the time it was published, there are two main limitations on the applicability of its results for our study.

- The study was completed in 2006 and since then there have been a number of developments regarding potential uses of the digital dividend, notably, wireless broadband which was in its infancy at the time of the study. UK mobile operators had yet to deploy HSPA (Vodafone launched the first commercial HSDPA service in the UK in June 2006), and consumer take-up

146 Ofcom (2006), "Digital Dividend Review".

147 Defined as mobile multimedia in Ofcom’s report.

148 Defined as PMSE in Ofcom’s report.

149 Although Ofcom states that this may underestimate the private value generated by SAB/SAP.

was low. As a result, interest in using the 470–862MHz band for wireless broadband was less developed. For example, the 790–862MHz sub-band had yet to be proposed. Therefore, this study may underestimate the value that wireless broadband could generate. On the other hand, interest in using the digital dividend for broadcast mobile TV was greater in 2006 than today, although the business model was unproven. As discussed in Section 4.2.2, this interest appears to have diminished.

- Ofcom have not published detailed information regarding the private value model, only high-level results are available publically.

Analysys Mason and Hogan & Hartson's study for ARCEP

Analysys Mason/Hogan & Hartson undertook a study for ARCEP during which we estimated the value of potential uses of the digital dividend in France. Again this valuation included both the private and external value of potential uses (external value relating to this report is summarised in the Section 9.3 below). The study demonstrated that in France, allocating a sub-band of 72MHz within the 470–862MHz band to electronic communication services would add more value to the economy than allocating all of the 470–862MHz band to audiovisual services only. Indeed, this study illustrated that in France, sharing spectrum between these services would increase private value by over EUR25 billion between 2012 and 2024, which is more than allocating the digital dividend to DTT alone. The conclusions of this study are summarised in Figure 9.5 below.

Use	*Main conclusions*
DTT	The six multiplexes already launched in France would create EUR36.7 billion of private value (discounted value over 12 years[150]). Allocating the whole digital dividend to DTT (i.e. increasing the number of DTT multiplexes from 6 to 12)[151] could increase this private value by EUR1.26 billion (discounted value over 12 years).
Broadcast mobile TV	Using the digital dividend to create one broadcast mobile TV multiplex could create EUR2.0 billion of private value (discounted value over 12 years). Using the digital dividend to create a second broadcast mobile TV multiplex could increase the private value by EUR0.7billion (discounted value over 12 years).
Wireless broadband	Allocating 72MHz of the digital dividend to wireless broadband services could create EUR26.2 billion of private value (discounted value over 12 years). It was assumed that if the 470–862MHz band was not available for wireless broadband, then 2.6GHz spectrum would be used to provide this service.

Figure 9.5: Private value estimates of Analysys Mason and Hogan & Hartson's study for ARCEP [Source: ARCEP, 2008]

150 The study for ARCEP valued these services over the period 2012–2024 (discounted to 2008).

151 In France there is a consensus that the digital dividend is considered as *all* spectrum that can be made available in addition to the six multiplexes already allocated to DTT and mobile TV.

When considering these results it is important to account for the specific characteristics of the French market. Relative to other Member States, France has a large rural population. It is likely to be very costly or even unviable to deploy high-speed broadband to these rural areas using fixed or cable networks. Therefore, wireless broadband may generate more value in France than in other Member States.

Analysys Mason study for the Dutch Ministry of Economic Affairs

Analysys Mason undertook a study for the Dutch Ministry of Economic Affairs during which we estimated the value of potential uses of the digital dividend in the Netherlands. Again this included both the private and external value of potential uses (external value relating to this report is summarised in the Section 9.3 below). The study demonstrated that in the Netherlands, continuing to make spectrum available for the existing five DTT multiplexes can be expected to yield significant economic benefits, primarily from competition between TV platform leading to lower prices for TV services. Using the 790–862MHz sub-band for next-generation wireless broadband services (e.g. LTE) could potentially create twice as much value than if the spectrum were allocated to broadcasting (DTT or mobile TV). The conclusions of this study are summarised in Figure 9.6 below.

Use	*Main conclusions*
DTT	Using the digital dividend to deploy one additional DTT multiplex (for either SD or HD services), in addition to the five multiplexes already operating in the Netherlands, could create between EUR0.8 billion and EUR0.9 billion of private value (discounted value over 22 years).
Broadcast mobile TV	Using the digital dividend to create one broadcast mobile TV multiplex could create between EUR0.2 billion and EUR0.9 billion of private value (discounted value over 22 years).
Wireless broadband	Allocating 72MHz of the digital dividend to wireless broadband services could create between EUR0.5 billion and EUR6.9 billion of private value (discounted value over 22 years). It was assumed that if the 470–862MHz band was not available for wireless broadband, then 2.6GHz spectrum would be used to provide this service.

Figure 9.6: Private value estimates of Analysys Mason's study for the Dutch Ministry of Economic Affairs [Source: Dutch Ministry of Economic Affairs, 2008]

Again, when considering these results it is important to account for the specific characteristics of the Dutch market. Compared to other Member States, the Netherlands has very high cable penetration. Therefore, the value generated from using the digital dividend for DTT may be lower than in other Member States.

Spectrum Value Partners’ study for Ericsson, Nokia, Orange, Telefónica and Vodafone

Spectrum Value Partners (SVP) completed a study in 2008 on behalf of a consortium of mobile operators that included Ericsson, Nokia, Orange, Telefónica and Vodafone. SVP’s goal was to model the optimal split between DTT and wireless broadband (using FDD spectrum) in the 470–862MHz band across Europe. To do so, SVP used three countries it believed were representative (Italy, Netherlands and Slovakia) and extrapolated the results of the study to estimate Europe as a whole. SVP concluded that freeing 80MHz (92MHz including a guard band) of spectrum for wireless broadband could generate a private value of between EUR111 billion and EUR180 billion for Europe. It also concluded that releasing the digital dividend now on this basis (instead of four years hence) would generate benefits of around EUR20 billion across Europe over 20 years.[152]

Despite this study being commissioned by a particular industry, our impression is that it is balanced in recognising the benefits from both broadcasting and wireless broadband. However, the results depend strongly on the assumption that the value generated in individual representative countries is scalable to the European level, and does not consider the potential benefits from uses other than broadcasting and wireless broadband. The study also focuses on identifying the optimal use of spectrum from a purely economic perspective; it does not consider the practicalities of identifying a common sub-band of 80MHz.

Oliver & Ohlbaum and DotEcon’s study for the EBU

Oliver & Ohlbaum and DotEcon’s study was sponsored by a consortium of public and private sector broadcasters under the auspices of the EBU. It provides a qualitative analysis of the relative value of leading potential uses, including DTT, cellular mobile and rural broadband systems. No attempt was made to quantify the private value that could be generated by potential uses but the study did provide a discussion of the relative incremental value of allocating spectrum to these uses. The study concluded that there was a “compelling case for intervention to set aside a proportion of UHF spectrum for digital TV”, but that the critical mass of spectrum required to support DTT varies between European countries. The study also argued that the economic case for

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152 To model the value of mobile broadband, SVP use data and methodology from a related study on the marginal effects of using digital dividend spectrum as opposed to more readily available 2.1GHz, 2.6GHz or re-farmed 900MHz spectrum. They estimate demand for mobile broadband services by breaking down the uses of mobile broadband into two main categories – laptops using datacards and mobile handsets – and using proxies to project consumer demand and roll-out of services for the next 20 years. They predict that 3G coverage should be roughly 80% by 2017, with the implication that a delay of 4 years in releasing the digital dividend would greatly reduce a network’s ability to substitute 470–862MHz for higher frequency bands, and so greatly increase the cost of provision

The study compares the incremental value created by mobile broadband with the benefits of allocating additional spectrum to digital terrestrial television. SVP assumes that all channels currently available on analogue will be simulcast in standard definition and then will be switched over to high definition following analogue switch off. The benefit of extra channels that would not otherwise be available is estimated and this provides an indication of consumer willingness to pay; the costs to the consumer of upgrading to digital are the subtracted giving an estimate of consumer surplus. Certain indirect benefits and externalities, such as increased revenue from advertising, are included in their value estimate.

other services was unproven. Specifically, in relation to three leading potential uses, the study offered the following assessments.

- There is a high overall value associated with DTT, but a significant proportion of this is public value. The majority of the value is associated with the provision of sufficient multiplex capacity to ensure the more popular TV programming channels are provided, and the long-term viability of the platform as a competitive alternative to cable and satellite. This competitiveness may be threatened unless there is sufficient capacity to manage upgrades in technology, including for HD services, without unduly disrupting existing services.

- The economic case for deploying cellular mobile broadband technologies depends on the ability of European countries to coordinate a common sub-band, in order to realise a common market for equipment and roaming. The study argued that it may be possible to realise much of the private value associated with mobile broadband using the 900MHz and 2.6GHz bands.

- Standalone broadband systems in rural areas (i.e. systems not deployed as part of wider cellular network) cannot be expected to generate much private value given the small target market. The study concludes that the case for broadband in rural areas depends largely on public value arguments and questions whether the incremental value is significant, given the potential availability of alternative technologies (e.g. cellular mobile broadband, satellite, WiMAX, DSL).

Overall, the study provides strong arguments in favour of some level of intervention to preserve DTT use in the 470–862MHz band, on the basis that DTT can provide substantial incremental value. The study also observes that the value from DTT may be vary greatly between Member States, which implies that different ways of dividing spectrum for allocation is likely to be appropriate. The analysis of other potential uses is limited, and the lack of a quantitative comparison of the incremental value of those uses makes it is difficult to draw any conclusions on what an appropriate allocation for each use might be. In relation to mobile broadband, the report is very negative about the prospects of European countries reaching a coordinated solution on adopting a suitable sub-band, based on observations at the time about the very different approaches planned by some leading Member States. Subsequently, there has been significant progress at both European and national levels to identify a common sub-band.

SCF's study for Deutsche Telekom

SCF's study, "The Mobile Provide", was completed in 2007 and was sponsored by T-Mobile/ Deutsche Telekom. The study compares two possible scenarios for the allocation of the digital dividend, which is defined as being approximately 400MHz of spectrum: "Broadcast Media Rules", in which 70% of the digital dividend is allocated to DTT (about 280MHz), 10% to wireless broadband (about 40MHz) and 20% to military and other uses; and "The Mobile Bazaar", in which 60% is allocated to mobile services (about 240MHz), 25% to DTT (about 100MHz) and 15% to military and other uses.

SCF concludes that the use of the digital dividend for wireless broadband services would be very positive for the European economy. By comparison, using the spectrum for DTT would have much less impact on the economy. The difference is mainly due to the significant productivity gains throughout the European economy coming from the investment in wireless communications, and driving GDP growth. For instance SCF estimated that "The Mobile Bazaar" approach would create EUR463 billion of "direct industrial output" across the EU, compared to EUR101 billion under the "Broadcast Media Rules" scenario.

However, these findings are difficult to compare to other studies. Firstly the study uses an unusual "micro-meso-macro linkage" framework, which quantifies the value generated by the uses from a small number of data points.[153] The approach also includes assumptions which appear more optimistic in "The Mobile Bazaar" scenario than the "Broadcast Media Rules" scenario. Notably, there is deemed to be no benefit from additional TV programming channels. Further, both scenarios assume that the terrestrial broadcast sector will be eclipsed by cable and satellite services across Europe in the long term. We believe that it is very questionable whether this will happen, and we anticipate that this significantly underestimates the value of using digital dividend spectrum for DTT. SCF appears not to have considered a scenario in which cable and satellite services do not eclipse terrestrial broadcasting.

A comparison of the private value studies

As each study has made very different assumptions or are focused on different countries, it is not straightforward to compare the results and to derive a value for each potential use of the digital dividend. Nevertheless, with the exception of the SCF study, there are some similarities in the findings, which are summarised in Figure 9.7 below.

[153] SCF estimates the value generated from "The Mobile Bazaar" scenario using half-yearly data from 2000 to 2004 for a number of variables: at the micro level, data on consumer expenditure on communication (mobile, Internet and TV) was used; at the meso level, data on penetration growth rates of wireless technologies was used; and at the macro level, EU-wide measures of GDP and employment were used. SCF calculated cross-correlation coefficients between micro and meso variables (and between meso and macro variables) and chose the highly correlated pairs for use in projections of meso (and macro) time series. To calculate the value of the "Broadcast Media Rules" scenario fewer variables were used: at the micro level, the households expenditure on television services; at the meso level, television revenues; and at the macro level, EU-wide measures of GDP and employment.

Use	*Main conclusions*
DTT	Most of the studies conclude that there is a high private value associated with terrestrial broadcasting, both as a medium for reaching consumers that are resistant to or unable to use other platforms, as well as a way to increase platform competition. However, the majority of this value is associated with a minimum level of TV programming channel provision, and this may vary significantly between Member States depending on local conditions. Additional provision of TV programming channels beyond the minimum adds only modest value. Based on the studies we could estimate the private value of six DTT multiplexes in each Member State to be between EUR130 billion and EUR370 billion across Europe (discounted value over 15 years).[154] This would require between 48MHz (using national SFNs[155]) and 384MHz (using MFNs and assuming on average eight spectrum channels are required per multiplex.) Also, the additional value generated by having more than six multiplexes is relatively small. For instance, the study for ARCEP concluded that increasing the number of DTT multiplexes from 6 to 12 only increases the private value by 3%. From the study for Ofcom, it can be extrapolated that adding one multiplex (to the six already deployed) could increase private value by between EUR4 billion and EUR30 billion. This would require between 8MHz (using a national SFN) and around 64MHz (using an MFN).
Broadcast mobile TV	The private value associated with broadcast mobile TV was only estimated in the studies for Ofcom and ARCEP. By scaling these results to the EU, they indicate that the total value of allocating one multiplex to broadcast mobile TV across the EU could be between EUR2.5 billion and EUR25 billion (discounted value over 15 years).[156] This would require between 8MHz (using a national SFN) and around 48MHz (using an MFN, assuming six spectrum channels are required).
Commercial wireless broadband	Most of the studies conclude that there is a high private value associated with the use of a sub-band within the 470–862MHz band for wireless broadband services. Based on the results of these studies, we estimate the private value could be between EUR50 billion and EUR190 billion (discounted value over 15 years) for 72MHz across all Member States.[157]
Wireless broadband for PPDR	It is very complex to associate any private value with wireless broadband for PPDR and no study estimates such value. WIK Consult published a white paper that discusses the value of this service (see Section 9.3 below), however, it focuses on the public rather private value of this service.

154 These figures are derived from the results of the ARCEP and the Dutch Ministry of Economic Affairs studies (on a per inhabitant basis) that have been scaled to the EU population. We have also linearly scaled all the results to the same discounted period (15 years); note that a more sophisticated approach is not possible as the profile of the cash flows is not in the public domain.

155 Although we recognise that further spectrum may be required to coordinate in border areas, and in order to provide regional content.

156 These figures are derived from the results of the ARCEP and Ofcom studies (on a per inhabitant basis) that have been scaled-up to the EU population. We have also linearly scaled all the results to a similar discounted period (15 years); note that a more sophisticated approach is not possible as the profile of the cash flows is not in the public domain.

157 These figures are derived from the results of the studies for the ARCEP and Ofcom, as well as the SVP study (on a per MHz and per inhabitant basis) that have been scaled to a 72MHz sub-band and to the EU26 population. This means that the estimate of private value generated by wireless broadband made in this study may underestimate the true value of the service. Due to limited data, we have also adopted a simplified method to scale all the results to a similar discounted period.

SAB/SAP	The value associated with SAB/SAP is not discussed in most of these studies. Only the Ofcom study estimates the private value generated by this service. When scaled to the population of all Member States this is between EUR0.9 and EUR4.3 billion (discounted value over 15 years) for one nationwide 8MHz channel and 32 channels interleaved with DTT.
Cognitive technologies	It is difficult to estimate the private value of using the digital dividend for cognitive technologies, as no service using these technologies has yet been launched and none of the studies have estimated such a value. However, in its consultation document on cognitive technologies,[158] Ofcom estimates the economic value of such services using these technologies in the UK to be between GBP170 million and GBP270 million per year (mainly from the cost savings these services could allow). Although Ofcom is not specific on how much spectrum would be required for these services. If extrapolated to the whole EU, this represents a private value of between EUR20 billion and EUR30 billion (discounted value over 15 years).

Figure 9.7: Estimated private value across the EU based on the above studies [Analysys Mason, DotEcon and Hogan & Hartson, 2009]

9.3 Estimates of the value of potential uses: external value

External value is the additional benefit to consumers or third parties not reflected in the value of the service to consumers. We have emphasised that it is important not only to consider the private value but also external value. The most relevant external value for potential digital dividend uses is public value, meaning the value that the public derives from uses because of their broader contribution to society.

Historically, concerns about public value have focused primarily on TV. In Europe, there is a long tradition of governments intervening to ensure the availability of particular types of TV content (e.g. public service or regional content). However, in principle, there is no reason why public value should not also be associated to some extent with other prospective uses of the 470–862MHz band, such as wireless broadband.

Estimating the magnitude of external value for any type of service, and in particular the incremental external value from the use of digital dividend spectrum, is much more challenging than estimating private value. Whereas we can use market data (prices, costs, quantities etc.) either for the relevant service or a comparable service for measuring the private value of a service, the

158 Ofcom (February 2009), "Digital dividend: cognitive access".

market (by definition) does not provide any direct indicators of its external value.[159] Possibly for this reason, some studies, such as the Spectrum Value Partners and SCF studies, largely do not recognise this category of value. Below we summarise the results of four studies that consider the incremental public value that could be generated by potential uses of the digital dividend:

- DotEcon and Dr Damian Tambini's study for Ofcom on the external value of potential uses of the digital dividend[160]
- Analysys Mason and Hogan & Hartson's digital dividend study for ARCEP on the economic benefit that could be generated from the digital dividend (the same study examined in Section 9.2 relation to private value)[161]
- Oliver & Ohlbaum and DotEcon's study for the EBU on the effects of a market-based approach to spectrum management and the impact on digital terrestrial broadcasting' (as above)[162]
- WIK Consult's report on the digital dividend for public safety use[163]

Note that none of these studies managed to quantify the incremental public value created by services; their conclusions are purely qualitative.

DotEcon and Dr Damian Tambini's study for Ofcom on the external value of potential uses

This study on the external value of potential uses was the first digital dividend study to investigate the scope for services other than DTT to generate external value. It also provides the most comprehensive investigation of the external value associated with different services, albeit only in the UK. The study team concluded that high public value may also be associated with a number of potential uses, in particular DTT (including local programming) and wireless broadband. However, the study also concluded that much of this value could probably also be realised by alternative delivery technologies or spectrum bands; an exception to this was core provision of DTT. A very high external value was associated with the existing DTT offer in the UK,

159 There are approaches that allow researchers to estimate the value of services for which no market price exists. For example, the value of offering access to a recreational facility for free might be estimated with reference to the change in property prices in the area served by the facility. However, these approaches are generally specific to particular types of services, depend on a set of rather narrow assumptions, and require significant amounts of data. For an overview of different econometric approaches for estimating the valuation of public goods, for example, see W W Pommerehne, 1987, *Präferenzen für öffentliche Güter: Ansätze zu ihrer Erfassung*, Tübingen, Mohr, or M L Cropper and W E Oates, 1992, 'Environmental Economics: A Survey', *Journal of Economic Literature* 302.

160 See footnote 126.

161 See footnote 141.

162 See footnote 144.

163 See footnote 104

notwithstanding the fact it can be largely replicated via cable or satellite; very little additional external value was associated with adding new TV programming channels.

The study followed two methodologies for estimating the external value of potential uses.

- Top-down: “This approach uses the results of market research to quantify the aggregate external value associated with consumer services. It does not distinguish between different sources of external value.”

- Bottom-up: “This approach compares different sources of external value … drawing on market research commissioned by Ofcom (referendum conjoint, chip allocation, ranking exercises and deliberative research) and wider information (such as public policy indicators and academic research).”

However, the results of the top-down method were not considered sufficiently reliable to determine dependable quantitative results. Instead, the study based its conclusions on the results of the bottom-up model, to rank each use according to its potential contribution to different sources of external value. The study identified six sources of public value (which it called ‘broader social value’):

- educated citizens (educational content, child-oriented services)

- informed democracy (benefits of services, access to latest technology)

- cultural understanding (reflecting and strengthening cultural identities; promoting diversity and understanding of other cultures)

- belonging to a community (either ‘virtually’; by connecting with other people with similar interests; or ‘locally’ in the sense of participating in a local community)

- access and inclusion (social inclusion and universal access, “social glue” provided by common references and forums, and access to public services)

- quality of life (promoting quality of life through access to technologies; work–life balance; and family life).

This list was derived from a review of accepted public policy (in particular previous work associated with the BBC Charter, the UK Communications Act and i2010) and market research conducted as part of Ofcom’s Digital Dividend Review. The study also investigated a further six sources of ‘other external value’, including investment spill-overs, network externalities, non-rivalrous consumption, health & safety, and the environment; however, in these cases, the external value contribution was generally rated as small relative to the six public value sources.

The authors acknowledged that the categories of public value “present formidable measurement challenges” but concluded “that survey results can indicate at least orders of magnitude”.[164] Figure 9.8 below is from their report.[165] It distinguishes the incremental public value generated by different potential uses of the 470–862MHz band for the six categories. In each case, the authors have made a qualitative judgement of the magnitude of each source of public value associated with each service. These conclusions are justified on the basis of evidence from a variety of sources, but particular emphasis is placed on the results from the market research including the following three question types.

- Referendum conjoint questions, in which respondents were confronted with a series of choices between different combinations of services and were asked to choose which they thought was better for the country as a whole. Comparing the results from those choices with the choices that one would predict on the basis of the private value associated with the different options should, in theory, provide insight into the differences between external and private values.

- Questions in which respondents were asked to assess and rank the candidate services on the basis of their own value and the wider value of services to all citizens.

- Referendum questions using chip allocation to reveal preferences for particular services, again by comparing results to private value.

	Educated citizens	*Informed democracy*	*Cultural understanding*	*Belonging to a community*	*Access and inclusion*	*Quality of life*
Existing DTT*	√√√ (1)	√√ (1)	√√√	√√	√√	√
Additional DTT	– (1)	– (1)	√	–	√√	√
Local DTT	√	√	√	√√	√	√
HD on DTT	√ ? (3)	√ ? (3)	√√ ? (3)	–	√ ? (3)	√ ? (3)
Mobile TV	√ ? (1)	√ ? (1)	√	–	–	√
Wireless broadband	√	√	√	√ ?(2)	√	√
PMSE	√	√	√	√	–	√
Home networks	–	–	–	–	–	√ ?

Note: indicative assessment only.
Extent of social value is rated between zero “–“ and three ticks, where zero = negligible or no value; √√√ = significant positive social value.
1 Value may increase if additional services are PSB.
2 Value will increase if ‘virtual participation and belonging’ is seen as equal in value to ‘real’ face to face participation and belonging.
3 The presumption here is that without additional spectrum, provision of highly valued content (such as existing PSB channels) in HD may be constrained. However, note that there is some uncertainty over the extent of this effect.

Figure 9.8: *Assessment of the importance of public value associated with use of UHF spectrum for* incremental *provision of relevant services [Source: DotEcon & Dr Damian Tambini, 2006]*

164 Id. DotEcon and Tambini (2006).

165 This is a copy of Table 8 from the study. Note that we have added an extra line for ‘existing DTT’ which is taken from Table 7, which considers the total value of services,

The main conclusions of the study in relation to the potential uses are summarised in Figure 9.9. The bottom-up analysis identified a number of sources of significant external value linked to the these potential uses. However, in most cases (SAB/SAP and some forms of DTT provision were identified as partial exceptions) the study concluded that "the availability of alternative frequencies or other platforms for provision of the same services means that realisation of this value is not wholly dependent on access to digital dividend spectrum." Perhaps the most notable conclusion is the high public value associated with the existing DTT services provided over six multiplexes in the UK, and comparatively tiny value from additional DTT programming channels. This conclusion is derived from the survey results in which respondents typically attached a high public value to the public service TV programming channels, which receive disproportionately high level of viewing on the analogue and DTT platforms, but relatively low public value to other TV programming channels. It is unclear whether this is a UK-specific finding or has broader implications for other Member States.

Use	*Main conclusions*
DTT	Broadcasting additional DTT programming channels to those provided by the existing six multiplexes, would only contribute significant public value through an "access and inclusion" aspect. Most public value is associated with the content provided on the existing public service broadcasters' TV programming channels. The provision of HDTV over DTT is likely to provide only modest additional public value, as it is widely considered as a luxury item, and it is content rather than picture quality that typically provides public value.
Broadcast mobile TV	Broadcast mobile TV is perceived as a luxury item and therefore has no significant public value associated with it.
Wireless broadband	Wireless broadband may provide significant public value if it enables broadband access where fixed line services are not available. However, the study concluded that the incremental public value associated with using digital dividend spectrum is small, as this service could probably be replicated using other bands, notably the 900MHz band.
SAB/SAP	SAB/SAP uses, such as wireless microphones and talk-back systems, are used extensively and contribute to a range of activities with high public value.
Cognitive radio/licence-exempt services	No significant sources of public value were found for licence-exempt services and cognitive technologies were not considered directly in this report.

Figure 9.9: Summary of DotEcon & Dr Damian Tambini's report for Ofcom [Source: Ofcom, 2006]

In its Digital Dividend Review consultation, Ofcom gave an indication of the public value as a percentage of the private value of each of the potential uses; this ranges from 5% to 15% of the private value. This figure, derived in part from the work undertaken by DotEcon and Dr Damian Tambini, indicates that the external value is relatively modest in size compared to private value. Note, however, that Ofcom's definition of the digital dividend is spectrum remaining after the provision of the existing six multiplexes is different from the definition used in this study, which is all spectrum not required to replicate analogue service provision (equivalent to just one multiplex in most Member States). Thus, the external value associated with the first six multiplexes may significantly exceed this level.

Analysys Mason and Hogan & Hartson's study for ARCEP

The public value of different uses of the digital dividend was also analysed by Analysys Mason and Hogan & Hartson in their report for ARCEP. Their report identified similar criteria to those used in DotEcon and Dr Damian Tambini's study for Ofcom:

- the development of education and access to information
- support for cultural exchange and community development
- social inclusion and resisting exclusion
- contributing to sustainable development
- regional development
- development of health public services and security for all
- the growth of France's competitive advantage
- R&D.

The conclusions reached are shown in Figure 9.10 below. Note that it is difficult to compare these results with the study for Ofcom as this study only considered the *absolute* public value rather then the *incremental* value generated through access to digital dividend spectrum.

Use	*Main conclusions*
DTT	DTT provides significant public value, especially through education, sharing culture and community building. It also contributes to the competitive positioning of France and its R&D. However, DTT does not significantly improve social inclusion. Further, a rich and diversified range of TV programming channels would help to promote the education of citizens and cultural exchange.
Broadcast mobile TV	Broadcast mobile TV provides similar public value to DTT. However, notably this service could potentially increase the digital divide, as services are unlikely to be deployed in the most rural areas.
Wireless broadband	Wireless broadband contributes positively to all sources of public value listed above.

Figure 9.10: Summary of conclusions from Analysys and Hogan & Hartson report for ARCEP [Source: ARCEP, 2008]

Figure 9.11 below is from the report. It summarises the external value of the different uses considered, in a scenario in which the digital dividend is shared between wireless broadband services and DTT.

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

Note: indicative assessment only.

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

Figure 9.11: Estimated importance of source of external value associated with use of digital dividend spectrum for DTT, mobile TV and wireless broadband [Source: Analysys Mason, Hogan & Hartson, 2009]

Oliver & Ohlbaum and DotEcon's study for the EBU

This study argued that there were high levels of public value associated with the provision of core TV programming channels on a sustainable terrestrial platform. It also questioned the public value generated by using digital dividend spectrum for wireless broadband in rural areas, given the small target market and potential availability of alternatives (such as 3G, satellite or WiMAX at other frequencies, and DSL provision).

In relation to DTT, the study used a broadly similar framework for assessing public value to the work undertaken by DotEcon and Dr Damian Tambini for Ofcom, but across all Member States. No additional survey work was undertaken. Rather, the study provides a brief assessment of the contribution of DTT to public value under six positive headings (the same for the Ofcom study) and one negative heading ("social bads"). The study concludes that: "It is apparent from this analysis that while the public value of broadcasting in general is high, it is disproportionately so in relation to terrestrial broadcasting. Further, the roll-out of DTT promises to increase the breadth and depth of the television experience provided to viewers."

The implication that a high proportion of the public value associated with DTT can be linked to terrestrial services is based on a number of observations. The report argues that the public value cannot be fully captured by use of alternative platforms, owing to the increased cost to viewers of obtaining and/or lack of availability of cable, satellite or IPTV services. For example, DTT use is very popular in many countries for second TV sets, owing to the free-to-view model and requirement for expensive set-top boxes for alternative subscription platforms. It is also the case that TV programming channels perceived to have high public value have much greater market share than on cable or satellite. Nevertheless, the report does not strongly differentiate between the absolute and incremental public value of DTT services.

Regarding other potential uses, the report does not provide a systematic review of the public value contribution across the six categories. With regard to wireless broadband, the report argues that public value is likely to be small, regardless of the private value of this service, given the availability of alternative spectrum at 2.6GHz and 900MHz. It observes that there may be high public value associated with broadband provision in rural areas, but questions whether digital dividend spectrum is required nationwide to deliver this service. Instead, if the service can be supplied either by existing networks using currently available spectrum bands, then incremental public value associated with use of the 470–862MHz band may be small. Alternatively, if broadband demand in rural areas is localised, it might be provided using interleaved digital dividend spectrum, in which case the opportunity cost of denying other services, such as DTT, would be small.

WIK Consult's report on the digital dividend for public safety (PPDR) use

WIK Consult's white paper on the use of digital dividend spectrum for a PPDR[166] wireless broadband network focused on public value. It stated that such a network would be a key asset in the development of public health services and security for all, and as such would sustain the quality of life of citizens across Europe.

Comparison of the external value studies

A limited number of studies have attempted to assess the external value associated with potential uses of the digital dividend spectrum. The most comprehensive study is the report by DotEcon and Dr Damian Tambini for Ofcom, which made extensive use of survey work in the UK. However, even this study was unable to quantify either the absolute or incremental external values associated with potential uses.

Some common themes do emerge across the main studies:

- Public value matters. The sources of public value identified in the studies, such as education and social cohesion, are highly valued by respondents, and communication services are perceived to have a role in building this value.
- The two service areas which are perceived as being most strongly associated with public value are TV (especially TV programming channels carrying public service content) and broadband, particularly in rural areas.

[166] Note that in this report WIK Consult refer to PPDR as PSS (public safety services).

- The proportion of public value can be attributed specifically to provision of these services using digital dividend spectrum is ambiguous. Both TV and broadband services could be supplied using other delivery technologies or spectrum bands, which implies that much of their public value might be realised by other means. In the case of TV, the suggestion that DTT has a central role in realising this value is closely tied to the legacy role of terrestrial TV and the cost of switching to other platforms. Such a suggestion may have considerable merit in Member States such as the UK and Spain, which have strong terrestrial platforms, but is weaker when considering Member States such as Denmark or Belgium, where terrestrial TV has negligible market share. In the case of broadband, the critical issue is whether the high-speed roll-out could be realised by networks using existing spectrum at 900MHz.

Ofcom appears to be the only commentator that has attempted to quantify external value – it estimates this at between 5–15% of private value for each service. This is broadly in line with the qualitative conclusions of the study by DotEcon and Dr Damian Tambini, although it should be noted that Ofcom's figures only refer to additional DTT services beyond the first six UK multiplexes. UK research suggests that the public value associated with the first six multiplexes may be considerably higher than this as a proportion of public value.

9.4 Conclusion

There have been a number of studies on the private value of various uses of the digital dividend. Each confirmed that there is an sizable private value associated with the digital dividend spectrum, in the order or hundreds of billions of Euros. However, certain potential uses appear to bring more private value than others; in particular there is significant value from using the digital dividend for DTT and wireless broadband. Other services, including SAB/SAP or cognitive radio, appear to provide lower levels of private value.

Most of these studies agree that the digital dividend is likely to be shared between several uses. As an illustration, in order to estimate the total private value that the digital dividend is likely to provide across the EU, the digital dividend could be used for:

- six DTT multiplex (for either SDTV or HDTV services) – however, this includes the first DTT multiplex, which strictly should not be included within the definition of the digital dividend, therefore, the estimate below should be viewed as an upper estimate
- one broadcast mobile TV multiplex
- wireless broadband services (72MHz of spectrum)
- SAB/SAP (one nationwide 8MHz channel plus around 32 channels of 8MHz on an interleaved basis with DTT).

Based on the results from the studies summarised in Figure 9.7 above, we can estimate that these uses together would generate between EUR150 billion and EUR600 billion of private value across the EU (discounted value over 15 years).

Some studies also considered the external value that potential uses of the digital dividend could generate. These studies suggest that many of the potential uses provide some element of public value. Indeed, there is strong evidence to suggest that the absolute public value associated with two of the services – DTT and wireless broadband (especially in rural areas) – is large. However, given the scope to replicate potential uses using alternative platforms or spectrum bands, it appears that the incremental public value is typically modest.

One possible exception to this is DTT, where survey work conducted by Ofcom indicated that there may be significant incremental public value associated with providing a critical mass of DTT programming channels. It seems reasonable that these UK-specific findings may be applicable to other Member States where terrestrial TV has an established role, but not necessarily to other Member States where terrestrial TV penetration is modest. Note that, in all cases, the incremental public value of extending DTT provision beyond this critical mass appears very small. There is also no clear definition of this critical mass and presumably it will vary between Member States.

None of the studies provide a clear, reliable basis for quantifying the public value. The only quantitative benchmark available is from Ofcom, which estimates incremental public value for all uses (except the first six DTT multiplexes) at between 5% and 15% of private value. If we extrapolate this estimate across the EU, we can estimate incremental external value at between EUR7.5 billion and EUR90 billion, excluding any additional benefits from having a critical mass of DTT.

Based on the above figures, we estimate the total value that could be generated by the digital dividend (private value plus external value) is estimated to be between approximately EUR150 billion and EUR700 billion across the EU (discounted value over 15 years).

10 Demand for the digital dividend

This section explores the potential demand for spectrum for DTT and wireless broadband in the 470–862MHz band. As explained in Section 9.1 above, these are likely to be the highest value users as well as those that use the largest amount of spectrum in the 470–862MHz band. We have considered demand in the medium term, with a specific focus on the periods immediately after analogue switch-off.

For these two uses, we have developed a wide range of spectrum demand scenarios, resulting in low, medium and high demand for spectrum. However, the demand in individual Member States may vary significantly within these ranges. For example, demand for DTT in one Member State may be high, whereas demand in another Member State may be significantly lower, perhaps due to the wide availability of other TV platforms (e.g. cable, satellite, IPTV). These scenarios are necessarily at a high level to reflect a broad range of possible outcomes. We have deliberately considered a wide range of scenarios, including some radical scenarios, in order to understand their impact on spectrum demand.

Note that few of the existing studies on the value of the digital dividend have considered the spectrum demand for potential uses of the band explicitly, and none in any detail. Note also that our scenarios are based on forecasts of consumer demand, without any policy intervention to promote a particular type of service or delivery platform. We do not consider here the possibility that demand for a particular use and delivery platform may be deficient in terms of maximising value for society, for example because there are public value benefits associated with its provision.

10.1 Demand for spectrum from DTT

In this section, we firstly examine the potential demand for DTT services. We then translate this *service* demand into *spectrum* demand in the 470–862MHz band, using a range of DTT technologies and deployment scenarios.

Demand Forecast 1: non-linear and interactive TV becomes the norm

This is an extreme scenario in which the vast majority of consumers would demand two-way interactive services, including rich on-demand offers. Such services are readily available via cable and IPTV platforms, but are not available on broadcast platforms such as DTT and, to a lesser extent, satellite.

In this scenario, hybrid DTT/IPTV business models[167] are not prevalent, because of demand for interactive and on-demand services. As a result, DTT demand progressively disappears, leading to a situation where DTT broadcasting is switched off. The evolution in the number of TV programming channels supplied is illustrated in Figure 10.1 below.

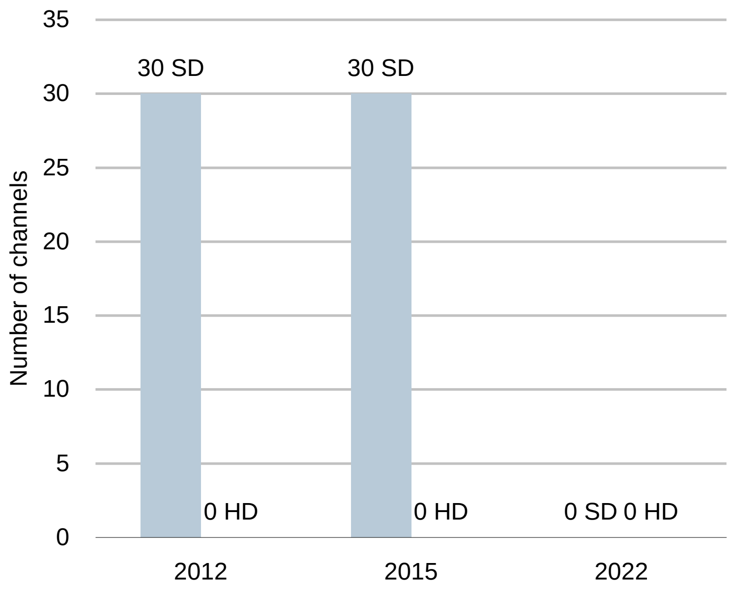

Figure 10.1: Demand Forecast 1 for DTT [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009] (SD means standard-definition TV and HD means high-definition TV)

Although an extreme scenario, it is most likely in Member States where cable and fibre-based broadband are very successful and cover a large proportion of the population (at least 90%, possibly up to 95% as in Belgium and the Netherlands). In most other Member States, it is unlikely that the fast broadband infrastructure would achieve sufficient coverage to change viewing habits so significantly in the timeframe considered.

Demand Forecast 2: the principle TV offer remains DTT

DTT would remain a mass-market TV platform, complemented by a high-speed broadband able to deliver streamed or multicast IPTV, delivering more TV programming channels and on-demand content than DTT. A large proportion of households would continue to receive satellite and cable services for a richer range of TV programming channels. Some of the more popular DTT programming channels would be available in HD. IPTV and high-speed cable broadband complement this offer with a wealth of HD on-demand content available to stream and download.

In this scenario, DTT provides sufficient TV programming channels to compete with the cable, satellite and IPTV platforms. During the Stakeholders’ Hearings, one stakeholder indicated this

167 These rely on set-top boxes, which combine standard DTT decoder with and IPTV terminal.

could be 25 to 30 TV programming channels, another mentioned 40 would be required. We assume that 32 would be available on the DTT platform, some in SD with others in HD, as shown in Figure 10.2 below. This scenario is essentially an evolution of the current situation in most Member States and it appears to be occurring already in several Member States such as the UK, France and Italy.

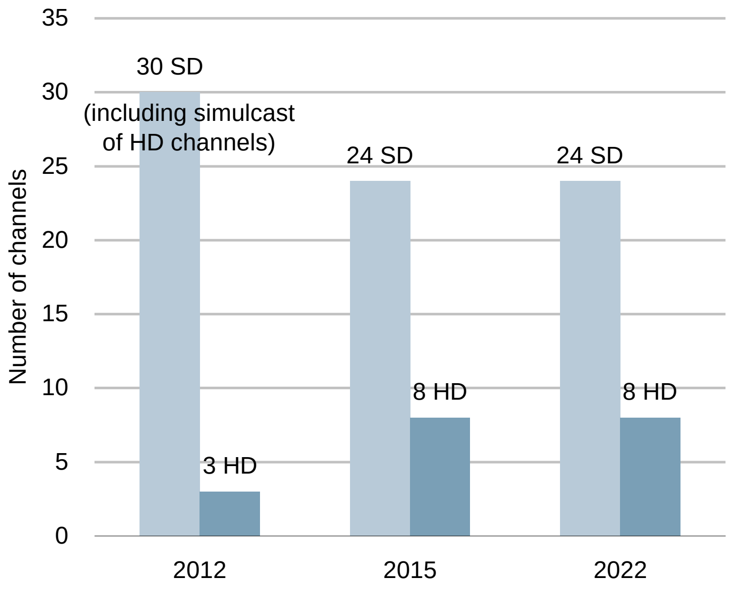

Figure 10.2: Demand Forecast 2 for DTT [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

Demand Forecast 3: DTT becomes a multi-channel, high-definition service

In this scenario, consumers expect DTT to fulfil most of their television needs. More TV programming channels are available and a larger proportion are HD. Of the relevant scenarios, this one places the greatest demand on DTT. The estimated change in the number of TV programming channels is shown in Figure 10.3 below.

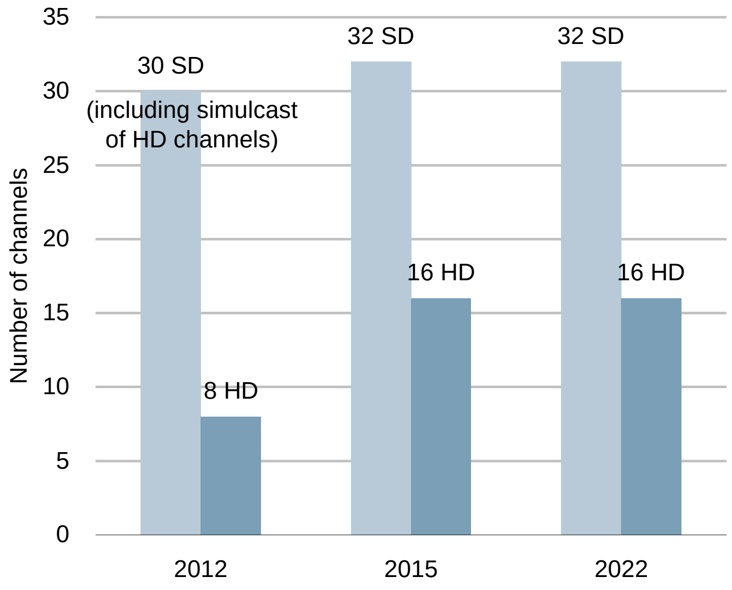

Figure 10.3: Demand Forecast 3 for DTT [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

Technical Scenarios 1–3

Translating service demand into spectrum demand involves making assumptions about the technical deployment of DTT. As explained in Section 4, DTT can be delivered using various technologies and topologies. The MPEG-2 compression technology is currently used in many Member States, although some Member States use MPEG-4 (and most Member States that have yet to deploy DTT are planning to use MPEG-4). Using MPEG-4, and specifically the H.264/MPEG-4 AVC variant, is approximately 100% more efficient than MPEG-2. The current DTT standard is DVB-T and a new generation, DVB-T2, is under development, which has the potential to increase multiplex capacity by up to 30%. Figure 10.4 below shows the capacity of a multiplex in terms of the number of possible TV programming channels, assuming different compression techniques and DVB standards. Note that these numbers are indicative and rounded, as the capacity of one multiplex can be optimised by multiplexing SD and HD, and MPEG-2 and MPEG-4 as required. This is discussed further in Section 4 above.

	DVB-T		*DVB-T2*	
	SD channels	*HD channels*	*SD channels*	*HD channels*
MPEG-2 compression	8	1	10	2
MPEG-4 compression	16	3	20	4

Figure 10.4: Illustrative TV programming channels per multiplex for DTT [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

Some Member States have deployed DTT multiplexes using MFNs. Such multiplexes typically require around eight spectrum channels each.[168] On the other hand national SFNs, such as those deployed in Spain, require just one spectrum channel per multiplex, although more channels are likely to be required for coordination purposes in border areas. Therefore, we have assumed that on average two spectrum channels are required per SFN multiplex.

Several permutations of the above technical options are possible. Essentially the choices of compression technology, DVB standard and network topology are largely independent (although DVB-T2 may make SFNs easier to deploy, due to it being more robust to self interference). For the purposes of developing a manageable number of spectrum demand scenarios we have used three technical scenarios.

- Technical Scenario 1 involves MFNs using DVB-T and MPEG-2. This scenario is currently implemented in many Member States, and is the most spectrum-intensive.
- Technical Scenario 2 involves MFNs using DVB-T and MPEG-4. This scenario is currently implemented in some Member States (e.g. Hungary, Lithuania) and is planned in several other Member States. Using this scenario, DTT networks can be expected to have twice the capacity as in Technical Scenario 1.
- Technical Scenario 3 involves SFNs using DVB-T2 and MPEG-4, except for one multiplex which is broadcast using an MFN in order to accommodate regional content. This is the most efficient network deployment currently foreseeable.

Estimated ranges of demand for spectrum from DTT

Combining each demand forecast with each the of technical scenarios, it is possible to estimate demand for spectrum that may arise from DTT. Figure 10.5 below illustrates the evolution of the demand for spectrum under Demand Scenario 1.

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168 In its study, Spectrum Value Partners assumed between eight and eleven spectrum channels per MFN multiplex depending on the their coverage requirements (see footnote 143).

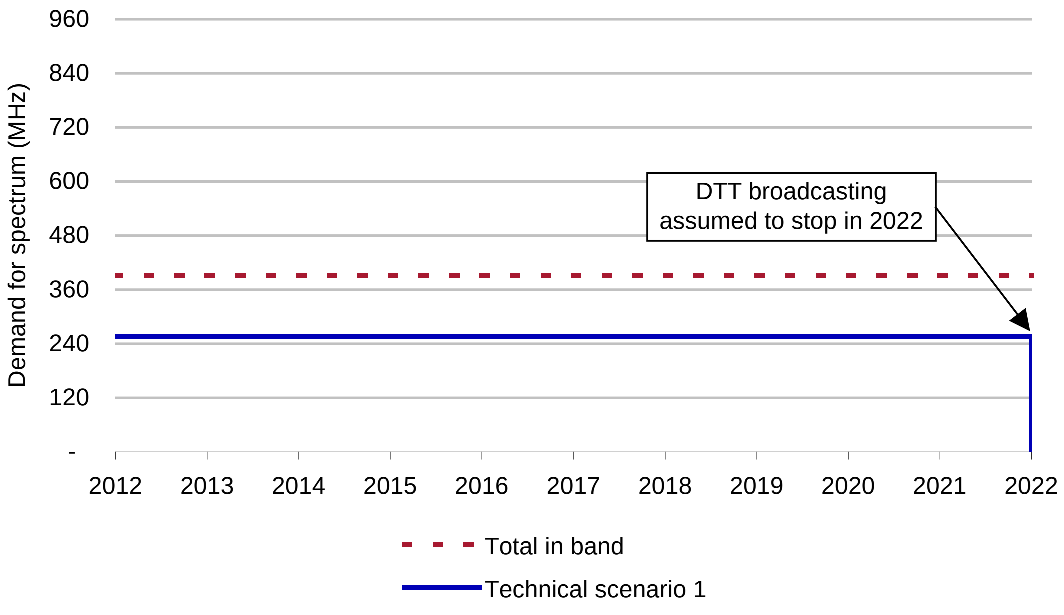

Figure 10.5: Demand for spectrum under Demand Forecast 1 [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

For this scenario, we have only modelled the DTT Technical Scenario 1 as it is unlikely broadcasters would invest in new technologies if demand for DTT disappears.

Figure 10.6 below illustrates the evolution over time of the demand for spectrum under Demand Forecast 2, for each of the three technical scenarios. We have assumed that HD channels are also available in SD in simulcast between 2012 and 2015. For 2015 onwards, we assume that:

- simulcast stops
- in Technical Scenarios 2 and 3, transmission switches to MPEG-4
- in Technical Scenario 3, transmission also switches to DVB-T2 and SFNs.

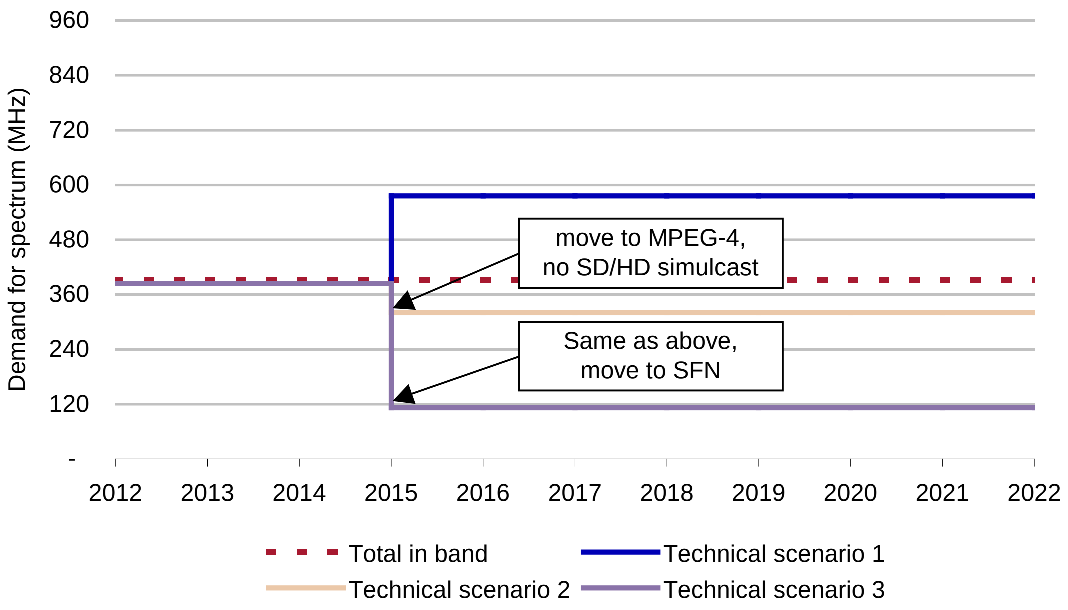

Figure 10.6: *Demand for spectrum under Demand Forecast 1 [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]*

Under Demand Forecast 2, MFNs remain a viable topology, although this would limit the amount of spectrum that could be available to other uses. SFNs would significantly decrease the demand for spectrum.

Figure 10.7 below illustrates the evolution over time of the demand for spectrum under Demand Forecast 3, for each of the three technical scenarios. We have assumed that HD channels are also available in SD in simulcast between 2012 and 2015. Because of capacity constraints, we have also considered that MPEG-4 will be required from 2012 in Technical Scenarios 2 and 3.

From 2015 onwards, we assume that:

- simulcast stops
- in Technical Scenario 3, transmission also switches to DVB-T2 and SFNs.

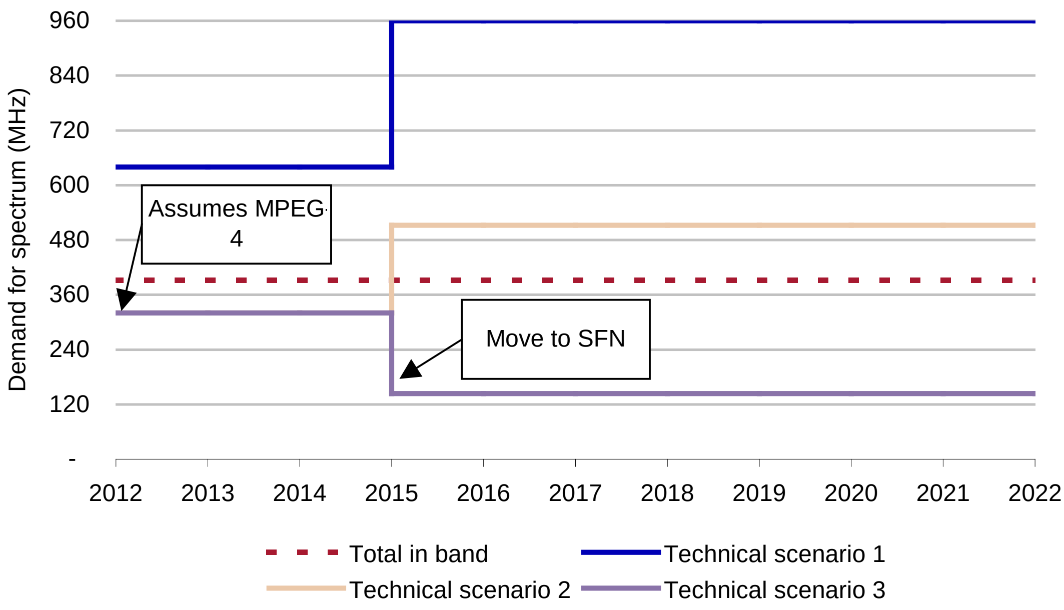

Figure 10.7: Demand for spectrum under Demand Forecast 3 [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

Under this scenario, MPEG-4 is a necessity early on, whilst in the medium-term SFNs must be deployed in order to limit the demand for spectrum from DTT to the available spectrum in the band.

Conclusion

Based on the high-level analysis in this section, demand for spectrum from DTT in the long-term may be as low as zero, and as high as 960MHz, which would of course exceed the capacity of the band. This is summarised in Figure 10.8 below.

Medium term spectrum demand from DTT (MHz)	*Technical Scenario 1*	*Technical Scenario 2*	*Technical Scenario 3*
Demand Forecast 1	0	0	0
Demand Forecast 2	576	320	112
Demand Forecast 3	960	512	144

Figure 10.8: Range of demand for spectrum from DTT [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

We can define three levels of spectrum demand for comparison with wireless broadband in the next section:

- low DTT spectrum demand: 0MHz
- medium DTT spectrum demand: 320MHz
- high DTT spectrum demand: 512MHz

Current DTT technologies require significant amounts of spectrum to deliver multi-channel television. Delivering HD content will require the use of more efficient technologies such as MPEG-4 and DVB-T2. In order to increase the number of channels significantly, broadcasters may also need to move towards the more efficient topology of SFNs. However, even if the whole band were to be used for DTT using the most efficient technology and topology, the maximum number of TV programming channels would still remain significantly lower than that available on satellite and cable.

10.2 Demand for spectrum from wireless broadband

In this section, we examine the spectrum demand from wireless broadband. Although take-up and traffic determine the amount of spectrum required, speed of connection demanded by consumers, the availability of alternative spectrum bands, and market structures are likely to be more significant drivers of the demand for spectrum. This demand will be determined by several parameters:

- the type of services demanded (mainly regarding the degree of mobility and the peak bandwidth offered)
- the resulting spectrum requirements per operator
- the number of networks deployed in rural areas, assuming different levels of radio-access network sharing
- the number of rural networks that can be deployed using the 900MHz band.

For the purpose of this section, we consider a country with four network operators. Most Member States have three or four networks operators, with a few sustaining five networks. We describe the parameters in detail below.

Wireless broadband is a new service, for which patterns of use have been evolving rapidly over the past two to three years. Future demand for these services could come from medium bandwidth mobile Internet access, or a very high bandwidth domestic or business access link similar in functionality to wired alternatives (cable, DSL, maybe even fibre). These different demand characteristics drive spectrum demand in two ways: higher demand in terms of simultaneous connections requires a larger number of spectrum channels, whilst higher bandwidth, particularly with LTE and its successors, will require wider spectrum channels.

As outlined in Section 4.1.3, the most advanced profiles of HSPA can deliver speeds of up to 14.4Mbit/s per 2×5MHz, although actual speeds are likely to be significantly lower. This could, for instance, depend on demand in a particular cell and the distance between the user and the base stations. LTE will provide theoretical speeds of above 100Mbit/s (though again actual speeds are likely to be lower than this headline) with larger, 2×20MHz spectrum channels.

In the long term, new releases of the most advanced wireless technologies may generate significantly increased demand for spectrum. LTE Advanced, which will be developed as 3GPP Release 10, will enable the aggregation of up to 100MHz of spectrum to achieve very high bandwidths for consumers. Very few details are available regarding the timeframe of availability of this technology, but it is unlikely to be commercially available before 2017.

In urban areas, all operators are likely to deploy wireless broadband services to meet consumer demand. In rural areas, however, operators may choose to share spectrum and deploy common networks. This will influence the demand for digital dividend spectrum, because these low frequencies are most suitable for network coverage, particularly in rural areas. The number of rural wireless broadband networks deployed in each Member State will in turn determine the amount of spectrum that is required in total.

The spectrum most suitable as a substitute for the digital dividend spectrum, in terms of propagation characteristics, is the 900MHz band. The band is 2×35MHz in size and is currently available throughout the EU to provide GSM services. This band is typically split between one to three operators, although as spectrum refarming develops, spectrum holdings may change. It is likely that some of this will continue to be used to provide coverage for GSM networks. However, some of the band is likely to be used for wireless broadband services, although the exact amount of spectrum and timing of this may vary between Member States.

Demand and supply scenarios influencing the demand for spectrum

We have developed four high-level scenarios combining various demand and supply constraints, in order to assess a range of demand for spectrum that may arise from wireless broadband services.

Demand Forecast 1: Mobile broadband is moderately successful, offered bandwidth remains low

In this scenario, wireless broadband would complement fixed broadband and subscribers accept lower speeds for a mobile service. Typical user experience would remain in the order of 2Mbit/s. Operators could therefore provide a broad range of services with only 2×10MHz of spectrum, similar to that currently used by most operators for 3G services. This would enable two rural networks to be deployed in the 900MHz band from 2012. In this scenario, we assume that these would be the only two networks deployed in rural areas, and that the other two operators either provide patchy rural coverage, or agree network sharing or national roaming arrangements with the networks. Consequently, there would be no demand for digital dividend spectrum from wireless broadband in this scenario.

Demand Forecast 2: Mobile broadband is ubiquitous, offered bandwidth remain low

This scenario is similar to the Scenario 1, although ubiquity of coverage would be a key competitive differentiator. This would create an incentive for operators with access to 900MHz spectrum to not share their networks, and would also mean that the other two operators demand access to low-frequency spectrum for coverage. In this scenario, two operators would demand 2×10MHz each of digital dividend spectrum, resulting in a total demand of 40MHz (plus duplex band spacing).

Demand Forecast 3: Mobile broadband is ubiquitous, rural households demand high bandwidths for fixed substitute

In this scenario, wireless broadband would be a ubiquitous mobile service. In addition, wireless broadband is used as the main Internet access medium in some rural areas where the availability or quality of other platforms (e.g. cable, DSL) is inadequate. These rural households would demand bandwidth of about 10Mbit/s, which would require network operators to use 2×20MHz carriers. This limits the number of networks that can use the 900MHz band to one only. The three remaining networks, therefore, would demand digital dividend spectrum. Under this scenario, demand for digital dividend spectrum will therefore be three times 2×20MHz of spectrum, or 120MHz in total (plus duplex band spacing).

Demand Forecast 4: Very high bandwidth is demanded in rural areas

This scenario envisages a situation in which fibre deployments are ubiquitous in urban and suburban areas, potentially creating a deep digital divide with rural areas, where such deployments would be prohibitively expensive. In this context, rural households would demand very high speeds to benefit from the same applications as urban households, most likely between 50 and 100Mbit/s. LTE-Advanced (3GPP Release 10) would enable such speeds, provided that a large amount of spectrum can be aggregated into large carriers. For the purpose of this scenario, we have assumed that this would occur from 2017,[169] and that the spectrum required would be in the order of 120MHz (2×60MHz FDD or 120MHz TDD) per network. In this scenario, the spectrum

169 3GPP Release 8 (LTE) is likely be commercially available in 2011 or 2012; accounting for the necessary development time for further releases, this appears to be a realistic early estimate of the availability of 3GPP Release 10 (LTE Advanced) networks and terminals.

available in the 900MHz band would be insufficient to deploy even one network. We have assumed that two networks would be deployed in rural areas, with operators sharing radio-access networks or entering into wholesale agreements. Consequently, demand for the digital dividend spectrum arising from wireless broadband in this scenario would total 240MHz.

Estimated ranges of demand for spectrum from wireless broadband

The demand for spectrum from wireless broadband is summarised in Figure 10.9 below, based on the different supply and demand characteristics we have assumed for each scenario.

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

Figure 10.9: Ranges of demand for spectrum from wireless broadband [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

We have assumed this demand will be fairly stable over time, with the exception of Scenario 4 where technology availability is a limiting factor, as shown in Figure 10.10 below. This also illustrates that even under our most aggressive assumptions, wireless broadband is unlikely to demand all of the 470–862MHz band.

170 Either 120MHz TDD or 2×60MHz FDD.

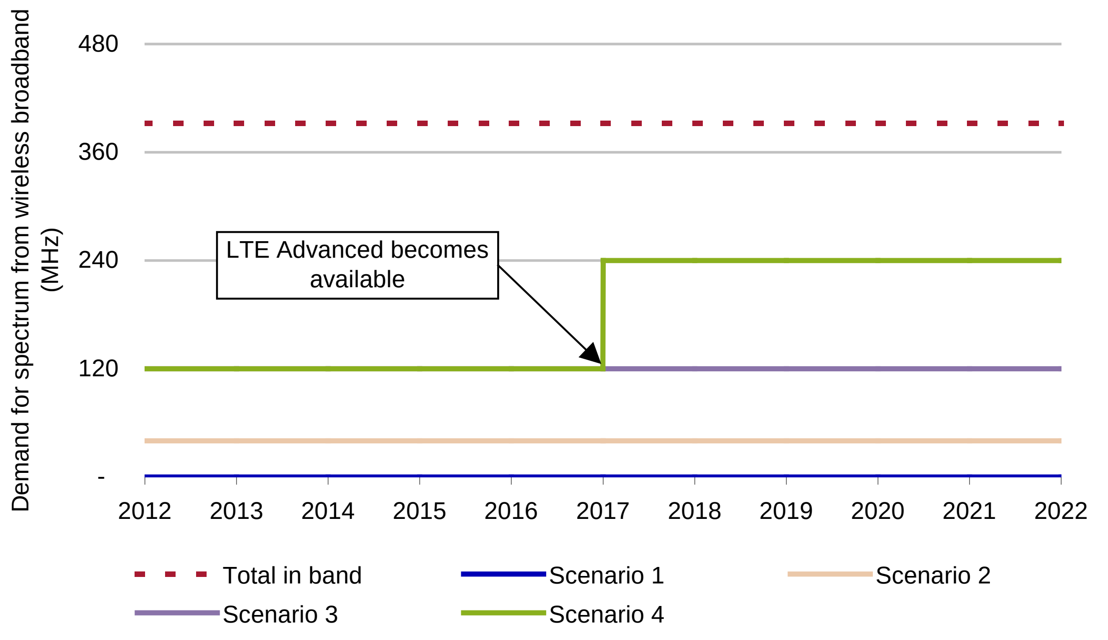

Figure 10.10: *Evolution over time of demand for spectrum from wireless broadband [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]*

Conclusion

Based on this high-level analysis, demand for spectrum in the long-term from wireless broadband may range from zero to as high as 240MHz, as shown in Figure 10.9 above.

We can define three levels of spectrum demand form wireless broadband for comparison with DTT:

- low spectrum demand: 0MHz
- medium spectrum demand: 80MHz (the mid-point of 40–120MHz)
- high spectrum demand: 240MHz.

The major factors influencing the demand for spectrum from wireless broadband are the level of demand for high-bandwidth services, the number of networks deployed in the market, and finally the availability of 900MHz spectrum for new technologies, particularly in rural areas.

10.3 Summary of spectrum demand for DTT and wireless broadband

All the scenarios described in Sections 10.1 and 10.2 represent a bound for the spectrum demand for DTT and wireless broadband. However, it should be noted that there is significant uncertainty about how demand for these services will evolve, and therefore how the demand for spectrum will develop. Also, as already mentioned above, individual Member States are likely to experience different levels of demand for DTT and wireless broadband, depending on factors such as geography, population density and availability of alternative platforms.

Figure 10.11 below illustrates the possible range of aggregated demand for DTT and wireless broadband in the 470–862MHz band based on our scenarios above. Grey cells denote combinations for which there is not enough spectrum in the band.

		Spectrum demand for DTT		
		Low (0MHz)	*Medium (320MHz)*	*High (512MHz)*
Spectrum demand for wireless broadband	Low (0MHz)	0MHz	320MHz	512MHz
	Medium (80MHz)	80MHz	400MHz	592MHz
	High (240MHz)	240MHz	560MHz	752MHz

Figure 10.11: Potential aggregated demand for digital dividend spectrum from DTT and wireless broadband [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

It is clear from this approach that demand for digital dividend spectrum is likely to exceed supply, in most combinations of demand from DTT and wireless broadband.

Part C: Rationale and options for EU-level action

11 The European dimension regarding the digital dividend and a framework for recommendations

In Section 9, we concluded that the value generated from potential uses of the digital dividend is likely to be very large, and that there is likely to be excess demand for spectrum in the 470–862MHz band. Thus, the value that is realised from the digital dividend will depend on how this scarce resource is divided among the various uses to which it could be devoted.

Optimally, the 470–862MHz band should be divided among uses in such a way that the total economic value generated over the long term is maximised. The components of the total economic value of the digital dividend are discussed in Section 9.1. These consist of the private value to consumers and producers, and wider external value to the economy as a whole and to society generally.

Because of varying situations in individual Member States, the amount of spectrum demanded by each potential use and the value generated by each are likely to vary between them. As a result, the optimum division of spectrum between uses may vary across Member States. On the other hand, as discussed extensively in Section 8, there is a strong European dimension regarding how the band should be used. Policy decisions in one Member State necessarily have an impact on neighbours, owing to requirements for frequency coordination and the importance of economies of scale in equipment. For most potential uses, it is beneficial if the same broad frequencies are used across Member States in order to realise economies of scale. Roaming is a particular issue for wireless broadband and (possibly) broadcast mobile TV services. There are also positive effects on national economies through greater growth, innovation and competition from the strengthening of European markets for equipment and services. Finally, some potential uses, most notably broadband, are central to European policy priorities, notably i2010. Thus, if Member States base their decisions on incomplete or inaccurate assessments, or take decisions in isolation from the broader European context, there is a risk that all Member States will suffer to some extent.

The ‘**European dimension**’ is the term used in this report for the rationale for EU-level action. Such action may be taken in order to meet EU policy goals, or to increase the total benefit to Member States over and above that which would be realised if Member States took uncoordinated action. This section briefly reviews the sources of the European dimension and outlines the approach taken in the remainder of Part C of this report in order to develop a recommended set of actions.

11.1 Sources of the European dimension

Coordinated action by the Commission regarding the digital dividend spectrum may be warranted based on (a) EU policy goals, (b) interference coordination due to high-power use, or (c) economies of scale and international roaming/interoperability. These factors are discussed below.

11.1.1 EU policy goals

The ways in which the digital dividend is used across Europe have the potential to contribute to EU policy goals, all of which can be seen as consistent with the overall aim of maximising the economic benefit of the digital dividend to society over time. These were described in Section 8.1 and are summarised here.

- At the highest level of European policy, any approach towards the digital dividend must realise horizontal policies, such as the completion of the internal market, competition, innovation and inclusion. As we describe in Section 11.1.3 below, the opportunities for exploiting economies of scale and international roaming imply a strong internal market dimension. Decisions with regard to the allocation of the digital dividend will have significant impacts on the scope for network and platform competition (e.g. in television or cellular broadband), technological innovation incentives and opportunities (especially if spectrum is set aside as an innovation reserve), and social inclusion (e.g. providing rural coverage).

- Looking specifically at spectrum management, the Electronic Communications Regulatory Framework emphasises the need for spectrum management authorities to rely on a harmonised set of objectives and principles, including the allocation and assignment of frequencies, to foster the efficient use of spectrum.

- Lastly, i2010 provides a policy framework for the ICT sector, with an agenda for creating jobs and growth, including the creation of a knowledge-based economy. Various sector-specific goals adopted by the Commission are linked to this policy framework, such as the March 2006 communication on bridging the broadband gap.

11.1.2 Interference coordination due to high-power use

The use of the 470–862MHz band for high-power DTT would result signals that travel over long distances (potentially hundreds of kilometres). This means that use of particular frequencies for high-power transmissions in one Member State could prevent the same frequencies from being used for other potential uses in neighbouring Member States. Because of this, the decision by just a small number of Member States to reserve digital dividend spectrum for DTT (for both national and regional services) might severely restrict the scope for neighbouring Member States to deploy new uses. Ultimately this could mean that the majority, if not all, Member States may have to use frequencies within the 470–862MHz band for DTT. As a result, this produces a "lowest common denominator" effect, where the amount of spectrum in the 470–862MHz band used for DTT across the EU would be driven by those Member States that derive the most value from DTT. This might result in a supply of DTT spectrum that is beyond the optimum for the EU has a whole.

In addition to the issue of the use of digital dividend for DTT, there is a European dimension regarding the potential application of more spectrally efficient transmission techniques, which requires further consideration. Such techniques include:

- the introduction of more spectrally efficient transmission technologies, for example the use of MPEG-4 instead of MPEG-2, and DVB-T2 instead of DVB-T
- the use of more spectrally efficient broadcasting network deployment topologies, in particular the introduction of SFNs.

We note from our research that there are significant variations in Member States' plans for adoption of the above techniques.

- Most Member States that have yet to introduce DTT are likely to move straight to using MPEG-4, while Member States that have already introduced DTT using MPEG-2 vary in whether they have plans to migrate to MPEG-4, and in the timing of this transition.
- Only the UK has firm plans to adopt DVB-T2 (for one multiplex, in order to provide four HDTV programming channels on that multiplex).
- SFN deployment plans vary. A small number of Member States (most notably Spain) already use national SFNs for some of their DTT multiplexes, while a number of other Member States (e.g. Denmark) have deployed regional SFNs. Many Member States have no known plans to use SFNs. The widespread deployment of SFNs across Europe would require the significant reorganisation of existing frequency assignments in Member States.

The use of advanced techniques (such as MPEG-4, DVB-T2 and SFNs) enables the delivery of the same number of DTT programming channels using less spectrum. This frees up spectrum either for more DTT or for an alternative use. Due to the common denominator effect identified above, a European dimension arises: Member States that are slower in adopting advanced broadcasting techniques may need more spectrum for DTT than those that are faster adopters, and this might impede the ability of other Member States to use the spectrum for other uses due to interference issues.

It should be noted that the widespread introduction of national SFNs could have a knock-on effect for some SAB/SAP users. As discussed in Section 4.1 above, some SAB/SAP users, particularly in the 'Larger-scale use within fixed sites' and 'Special events' categories, have demand for a large number of wireless microphones and IEMs, and therefore require use of a large number of spectrum channels. For this to be possible, a significant amount of interleaved spectrum needs to remain available, broadly equivalent to the amount available today. If national SFNs are widely deployed, this would impact the ability of SAB/SAP users to operate as many wireless microphones and IEMs at their events. The impact of this is likely to depend on the degree to which the availability of interleaved spectrum is reduced. If the reduction was small, then only the largest events would be affected, and users covering such events might have to use slightly fewer wireless microphones and IEMs. If the availability of interleaved spectrum was *significantly* reduced, many more events would be affected, and potentially the quality of the largest events might be compromised (e.g. it would be very difficult for some large-scale musicals to operate if some performers had to use wired microphones).

A further, related European dimension comes from the performance of DTT receivers. A discussed in Section 7.2 above, some DTT receivers are susceptible to interference from transmissions nine spectrum channels above the intended spectrum channel (the 'image channel' or the 'n+9 channel'). This may prevent uses other than DTT in the 470–862MHz, both within individual Member States and in neighbouring countries. The adoption of minimum interference rejection standards in receivers would solve this issue.

11.1.3 Economies of scale and international roaming/interoperability

Two advantages of a common frequency allocation and common adoption of standards for particular uses are the resulting economies of scale in equipment manufacture, and the greater scope for roaming/interoperability for consumers. Typically, it is significantly more cost-efficient for equipment manufacturers to produce network and consumer equipment to a single specification at a large scale, based on a single technology and a common frequency band, than to have to produce multiple, smaller-scale production lines for different markets. The reduced development times and greater certainty associated with harmonised choice of technology and frequencies also enables manufacturers to bring equipment to market faster.

For example, if a common decision was taken across the EU to deploy advanced broadcasting techniques (such as MPEG-4 and DVB-T2), this would enable DTT manufacturers to generate economies of scale and would give them better incentives to ensure that new DTT receivers incorporate these spectrally efficient technologies. Similarly, a common band plan for wireless broadband, as is being considered within the 790–862MHz range, particularly if aligned with other major markets (including both uplink and downlink frequencies for FDD operation), would also facilitate economies of scale and hence lead to lower consumer prices for handsets.

A detailed consideration of the potential economies of scale available for each of the potential uses is given in Section 8.7.

Furthermore, the cost-efficiency and feasibility of providing roaming services, particularly for wireless broadband are greatly improved if common frequency ranges and standards are adopted.

11.2 Our approach to developing a recommended set of actions

In the remainder of Part C we develop a recommended set of EU-level actions designed to enable the EU and individual Member States to maximise the benefit generated by the digital dividend, taking into account both the current situation and anticipated uncertainties.

The economic value generated by the 470–862MHz band will depend on how spectrum supply and demand are matched, as illustrated in Figure 11.1 below. Spectrum supply refers to the allocation of spectrum and the conditions of spectrum use in Member States, while spectrum demand refers to the (efficient) demand for spectrum to support various services to consumers.

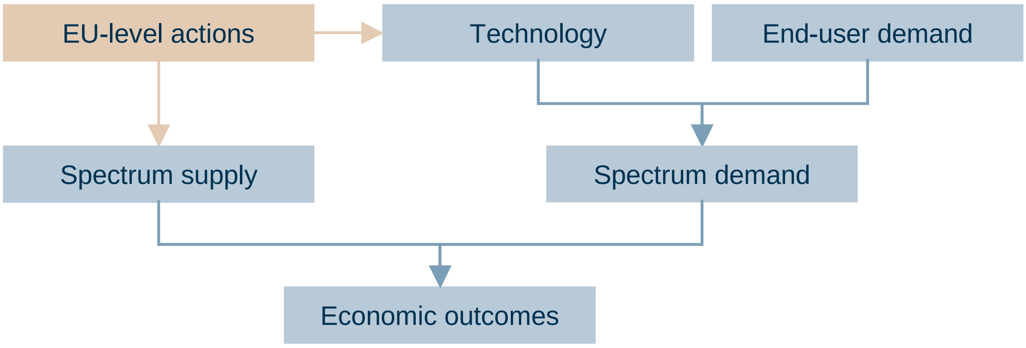

Figure 11.1: How the economic value generated by the 470–862MHz band will be determined [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

EU-level actions can influence the decisions of SMAs regarding spectrum supply. However, these actions can also have some impact on the choice and take-up of particular technologies.

Our approach to developing recommended EU-level actions is shown below. Rather than starting out with a menu of possible actions and analysing their effects, we analyse how economic outcomes might vary under combinations of very different scenarios for spectrum supply and demand. We then consider what EU-level action could be taken to promote those scenarios that emerge as the most beneficial. An illustration of this approach is provided in Figure 11.2 below, followed by a description of each step. These steps provide the plan for the remainder of Part C.

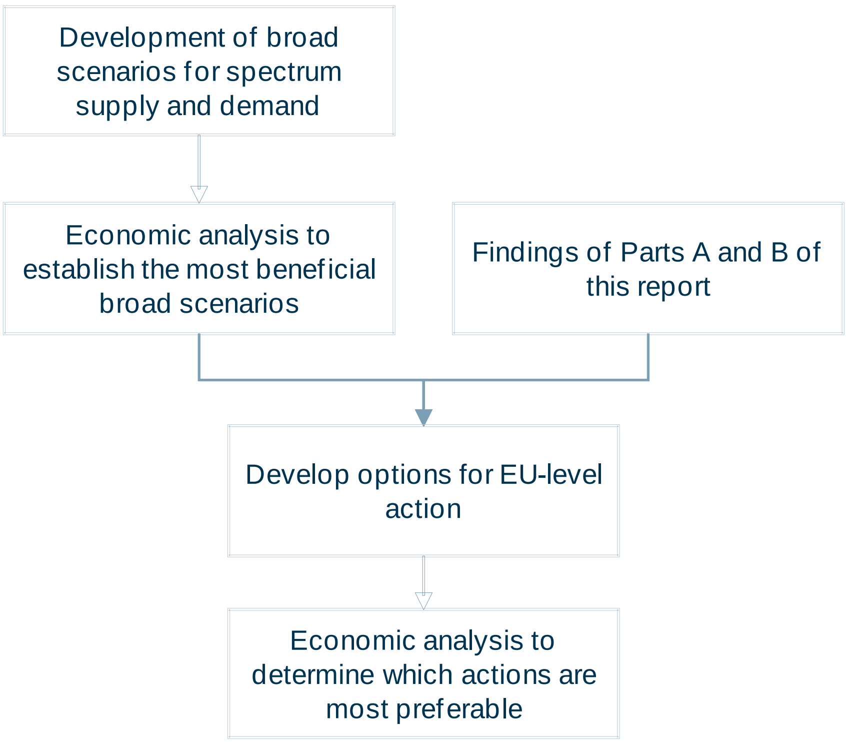

Figure 11.2: Approach taken to develop a recommended set of EU-level actions regarding the digital dividend [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

- **Development of broad scenarios for potential spectrum supply and demand for potential uses (Section 12)**. We begin by establishing a Reference Scenario for how the use of the 470–862MHz band is likely to develop in the absence of coordinated EU-level action. We then identify a series of scenarios for spectrum supply that represent alternatives to this Reference Scenario, as well as a series of scenarios for spectrum demand. These scenarios are "broad" in the sense that they span a very wide range of conceivable future division of uses of the digital dividend, and concentrate on the most important variables driving differences in the economic benefit realised for society.

- **Economic analysis to establish the most beneficial broad scenarios (Section 13)**. We then conduct analysis to evaluate the benefits and costs that might be expected if the above scenarios were to become reality, using top-down modelling based on the published analyses discussed in Section 8.2, and other sources. This allows us to identify which of these scenarios is/are the most desirable, while raising a number of further issues for detailed consideration.

- **Development of detailed options for EU-level action (Section 14)**. Next, we discuss and develop a series of options that may encourage the most desirable broad scenario(s), as identified in Section 11, to become a reality. This step also uses the outputs of Parts A and B of this report (e.g. national situations, technical restrictions) in order to identify appropriate options for action. In this step we consider holistic themes for actions such as adopting the 790–862MHz sub-band and strategies to promote the efficient use of interleaved spectrum. Within these themes we also consider specific actions regarding individual potential uses.

- **Economic evaluation of the options to determine preferable actions and select recommendations (Section 15)**. We conduct further quantitative and qualitative analysis of the implications of the actions identified above in order to establish which are the most preferable, before recommending a final set of actions. These recommendations are summarised in Part D of the report.

12 Broad scenarios for spectrum supply and demand in the 470–862MHz band

This section and the next assess how the magnitude of economic benefits from the digital dividend across the EU over the next 15 years could vary under different broad scenarios. These scenarios capture a range of possibilities concerning the division of the 470–862MHz band among different uses, and the demand for spectrum to provide services to consumers. The scenarios for spectrum supply and demand defined in this section are subjected to economic analysis in Section 12, leading to conclusions about which scenarios are most likely to maximise the incremental economic benefit to society (i.e. the value generated from using spectrum in the 470–862MHz band over and above the value that would be realised if a service was only provided by alternative means).

Note that our quantitative simulations are derived from our estimates of private value, and do not take into account the additional external/public value that could, in principle, be associated with certain uses of the digital dividend spectrum. As described in Section 9.3 public value is excluded from our calculations because there is insufficient certainty over the scale of this value source for any use to consider it quantitatively. Nevertheless, we do not believe that the absence of public value data significantly affects the validity of our findings, for two reasons. Firstly, based on our observations in Section 9.3, it seems reasonable to suppose that public value generated by potential uses is typically either unaffected by access to digital dividend spectrum (because there is an alternative platform that can deliver the same social value) or is positively correlated to the private value. Secondly, at each stage of our modelling, we have considered the role of public value on a qualitative basis.

12.1 Modelling framework

The economic impact modelling is based on previous research on the economic benefits of the digital dividend discussed in Section 9.1, plus other sources of information, primarily on costs. The modelling is necessarily top-down; that is, we do not attempt to model individual Member States in detail. For the main potential uses of the spectrum, we use (a) the evidence from previous studies on the incremental private value of the services that could be provided assuming the level of spectrum supply specified in each of the supply scenarios, coupled with (b) estimates of the costs of network alterations or deployments and consumer equipment upgrades that might be required. This information is then used to quantify, at least approximately, how differing divisions of the band among potential uses might translate into an economic value of the digital dividend across the EU. Given the uncertainties regarding the potential market for potential services, we also run sensitivities of these outcomes across a range of plausible scenarios for spectrum demand.

Note that we have considered not only spectrum supply scenarios that are relatively similar to the current situation, but also more radical and extreme spectrum supply scenarios (including the clearance of DTT from the entire 470–862MHz band). This is in order to understand whether such spectrum supply scenarios are optimal in more extreme spectrum demand scenarios.

Sections 12.2 and 12.3 describe the scenarios for spectrum supply and demand that are used in the modelling.

12.2 Spectrum supply scenarios

The spectrum supply scenarios refer to sets of decisions made by Member States on the use of different parts of the 470–862MHz band. There are many conceivable ways in which the 470–862MHz band could be divided among potential uses, and many possibilities for how these uses might change over time. To keep the number of scenarios and combinations manageable, while focusing on the main determinants of the economic benefit to the EU, we have made some simplifications.

First, as discussed in Section 9.1, current indications are that two main uses – DTT and wireless broadband – will be the dominant sources of spectrum demand and also the main sources of economic value for the foreseeable future. Our spectrum supply scenarios therefore focus on the split between these two uses as a first approximation in assessing the impact of different allocations. The important issue of how provision should be made for other currently identified potential uses is deferred until the next stage of the analysis (addressed in Sections 13 and 14). However, our modelling does allow for a scenario in which a major new use emerges that is of comparable value to wireless broadband. Note that this new use could be an evolution of what we know today as wireless broadband, or it could be an entirely new use altogether.

The second simplification is to limit our attention to just four scenarios. These scenarios span a representative range of possibilities with respect to the core split between DTT and wireless broadband or other uses.

- **a Reference Scenario** representing the likely outcome in the absence of EU-level coordination.
- **Scenario 1** considers a situation in which the 790–862MHz sub-band is adopted throughout the EU for uses other than high-power uses, whilst 470–790MHz is used for high-power DTT. This is desirable for some Member States.
- **Scenario 2** is an extension of Scenario 1 in which, at a later stage, DTT is further constrained to a ‘core’ band (between 470MHz and *X*MHz for some value of *X*), which is more limited than Scenario 1. The 790–862MHz sub-band and the resulting second sub-band of *X*–790MHz are available for common or varied uses. As explained below in Section 12.2.3, we use a value for *X* of 694MHz.

- **Scenario 3** is a radical scenario in which high-power DTT is cleared from the band. In this scenario it is likely that cable, IPTV and satellite would become the main television platforms, although some Member States may decide to deploy lower-power DTT. This scenario makes the spectrum maximally available for other uses, principally wireless broadband, and other major technologies and/or services that may emerge in time. This is an extreme and largely theoretical scenario – we note that realising this scenario would, in practice, be politically very sensitive, and that any decision to implement it would need to be a political one.

These scenarios are illustrated in Figure 12.1 below:

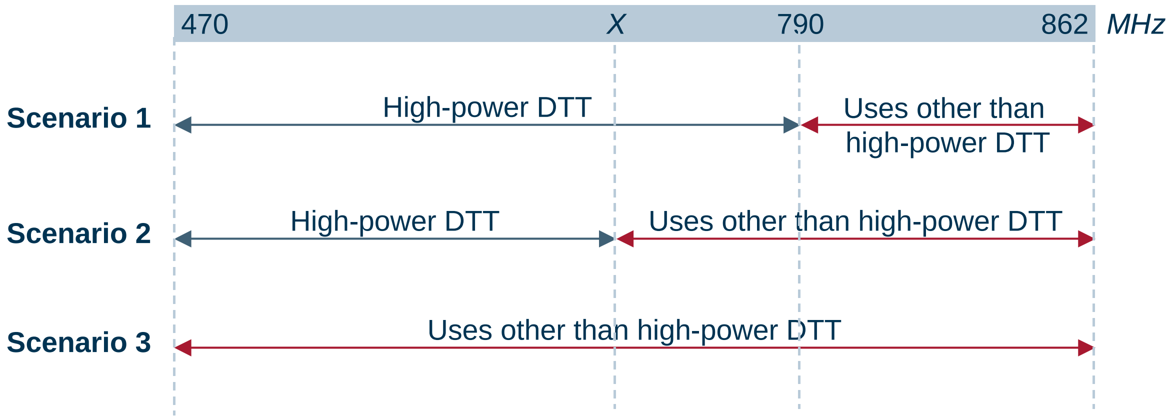

Figure 12.1: *Spectrum supply scenarios for the 470–862MHz band [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]*

Note that Scenarios 1 to 3 represent escalating levels of difference from the Reference Scenario.

Each of the scenarios for spectrum supply is premised on specific timings, although these could vary. The sensitivity of the estimated economic outcomes to variations in the timing of changes in spectrum allocations is considered in later analysis, where we also explore the trade-offs between providing certainty and retaining flexibility to respond to the uncertain development of spectrum demand.

12.2.1 Reference Scenario: the likely outcome in the absence of EU-level action

Annex A describes in detail the situation as of January 2009 regarding the use of the 470–862MHz band in 23 Member States. It also explains the situation in each Member State once analogue broadcasting is switched off. On the basis of this information, as well as information recently published by Member States, Member States can be divided into three broad groups:

- Eight Member States (Denmark, Finland, France, Germany, the Netherlands, Spain, Sweden and the UK) have announced plans to either allocate the 790–862MHz sub-band to wireless broadband, or to award it in a way that is suitable for wireless broadband. Only the UK has indicated that it plans to make some additional spectrum available for uses other than DTT, beyond this sub-band.

- Malta has decided to make use of the whole 470–862MHz band for high-power broadcasting uses.

- All the other respondents (14 Member States) have indicated that they are still undecided on the use of the 470–862MHz band. The four Member States that did not reply to the questionnaire (Belgium, Italy, Poland and Greece) have been included in this group for the purposes of our modelling.

It is difficult at this stage to assess the extent to which Member States that are undecided may decide to follow one of the two options identified above. For the purposes of our modelling work, we have made some broad assumptions about the approaches that individual Member States in this third category may take (in the absence of specific EU coordinated action). We have assumed that if the neighbours of a Member State decide primarily on one approach, then that Member State is likely to follow the same approach. For example, Belgium may be convinced to adopt the sub-band by the decisions of France, Germany and the Netherlands. Actions of countries outside the EU will also affect the decisions of the Member States that border them. Russia and Turkey, for instance, are unlikely to cease using the spectrum in the sub-band in the medium term in the absence of active coordination, and this may be a strong barrier to those Member States that form the Eastern border of the EU adopting the sub-band.

Our Reference Scenario therefore assumes the following categories:

- 16 Member States will identify a 790–862MHz sub-band: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Ireland, Italy, Luxemburg, Netherlands, Portugal, Slovenia, Spain, Sweden, UK

- 11 Member States will retain high-power DTT in the whole band: Bulgaria, Cyprus, Estonia, Greece, Hungary, Latvia, Lithuania, Malta, Poland, Romania, and Slovakia.

Please note that the above assumptions do not pre-judge the outcome in each specific Member States – these are simply 'broad brush' assumptions that are required to facilitate our economic analysis. Note also that if no EU-level actions are taken, the decisions taken by Member States may vary from the above assumptions. However, at the time of conducting this economic analysis the above split of Member States appears to the project team to be reasonable. We have, however, conducted sensitivity analyses on this split, as explained in Section 13.3.3 below.

12.2.2 Scenario 1: high-power DTT is used in 470–790MHz, and a 790–862MHz sub-band is adopted for a common use

Scenario 1 is essentially an evolution from the current situation towards a 72MHz EU-wide sub-band (790–862MHz) in which high-power DTT is not used. If it is adopted in countries bordering the EU, this sub-band is likely to be available throughout the EU. Our modelling assumes that one group of Member States will be able to adopt the sub-band as soon as analogue switch-off (ASO) is completed in 2012, while another group will only be able to do so in 2015 due to the impact of interference from bordering non-EU states.

In principle there are two variants to this scenario according to whether the sub-band is deployed for a variety of lower-power uses[171], which may include lower-power DTT, for example, or be harmonised for a specific use. Since wireless broadband is likely to be the most common use of the sub-band in either event, this choice has a relatively minor effect on the estimated economic impact, compared with the issue of where the split between high-powered DTT and other uses is located. We therefore assume that all of the sub-band is used for wireless broadband as a first approximation to assessing the overall economic benefits that would arise under this scenario.

The main benefit of Scenario 1 relative to the Reference Scenario is the fact that, within the sub-band most of the negative cross-border impact of high-power DTT would disappear. Cross-border coordination would be significantly easier than it currently is in the 790–862MHz sub-band. This would allow the economic benefits generated by wireless broadband to extend to these "desterilised" areas.

Economies of scale and the benefits of roaming across the EU would also increase, through the adoption of the sub-band in additional Member States, as well as the availability of any service using the sub-band across entire Member States.[172] The emergence of a lower-power sub-band throughout the EU is also likely to provide increased certainty to equipment manufacturers, which would enable them to invest in technology development earlier and in turn ensure that services using the sub-band can be deployed quickly.

Member States may have to negotiate bilateral or multilateral agreements to contain high-power DTT within frequencies below the sub-band. In some Member States, this scenario may mean that one or two DTT multiplexes disappear from the platform, which would result in a loss of consumer benefit. In Member States where lower-power DTT is deployed in the sub-band, the capacity of the DTT platform would be preserved, but at the cost of replanning part of the network. TV aerials may also have to be replaced or realigned.

Benefits of Scenario 1

In summary, the incremental benefits of Scenario 1, compared to the Reference Scenario, are as follows:

[171] Uses may vary from one Member State to the next; multiple uses of the sub-band within a given Member State may be possible depending on the configuration of the band and the services deployed.

[172] In the Reference Scenario, for instance, use of high-power DTT in Poland in the sub-band would have resulted in parts of western Germany not being able to use wireless broadband in the sub-band. In this scenario, in contrast, Poland could decide to continue using DTT in the sub-band with lower-power transmission, which would enable the whole of Germany to be covered by wireless broadband.

- In those Member States that would have retained high-power DTT in the sub-band in the Reference Scenario, wireless broadband can now be deployed and create value.
- In those Member States that would have adopted the sub-band in any case, no use is prevented in one Member State by high-power DTT in another, increasing the value generated by non-DTT uses in the sub-band.
- There is an increase in economies of scale (lowering costs) and roaming benefits (increasing consumers’ willingness to pay) if, as assumed, all Member States deploy wireless broadband in the sub-band.
- Equipment manufacturers may have greater certainty, which would enable wireless broadband technology to be available earlier than in the Reference Scenario, bringing forward the economic benefits involved.

Costs of Scenario 1

The incremental costs of this variant, compared to the Reference Scenario, are:

- A cost associated with the restrictions put on the amount of spectrum available for high-power DTT; this cost is a trade-off between the two following courses of action, whichever is least costly:
  - losing programming channels on one or two DTT multiplexes in some Member States (those that would otherwise continue with high-power DTT in the Reference Scenario); this would result in a loss of the value generated by these channels; or
  - upgrading the broadcasting networks to a more efficient technology (e.g. MPEG-4, DVB-T2) and/or topology (SFN), in order to create sufficient additional capacity to limit the loss of programming channels, and therefore retain the value they generate. Please note that we have based our modelling work on the improved spectral efficiency that is estimated to arise from these specific technologies (MPEG-4, DVB-T2) however this does not preclude the adoption of alternative advanced technologies with equal or greater spectral efficiency benefits.

- Additional frequency replanning costs to cover modifications to existing networks in order to change the frequency channels used by DTT transmitters; caused by the adoption of the 790–862MHz sub-band. This will also require a significant amount of cross-border coordination, which will entail costs for bilateral negotiations.

- Additional costs for repositioning or replacing aerials and set-top boxes (as a result of changes in the frequencies used by networks) as well as technology and topology upgrades. This depends in part on the current state of terrestrial TV aerials and receivers in each Member State (e.g. if aerials are essentially narrowband, it is likely that they will require changing and reorienting; if receivers are only MPEG-2 compatible and a network upgrade to MPEG-4 (for example) is required, then receivers will need replacing as well).

12.2.3 Scenario 2: high-power DTT is used in a core band, and two sub-bands are identified

Scenario 2 represents an extension of Scenario 1 in which the 790–862MHz sub-band is adopted in 2012, and high-power DTT is further constrained in the medium term (modelled as 2018 onwards) to a core band, 470–*X*MHz, where *X* is less than 790MHz. This has two major impacts:

- it reduces the capacity available for high-power DTT. As a result broadcasters will need to increase efficiency or switch to lower-power broadcasting in order to preserve or increase the number of TV programming channels on offer
- it enables a larger portion of the band to be used by lower-power uses than in either the Reference Scenario or Scenario 1.

There are potential variations on this scenario according to whether both, one or neither of the two sub-bands are employed for a common use across the EU or whether they support a variety of uses. For example, part of 694–862MHz could be used for lower-power DTT or as an ‘innovation reserve’ as described by participants in the Member States workshop and detailed in Section 4.1. Some of this spectrum could also be dedicated to uses such as PPDR or SAB/SAP, for instance.

For the purpose of modelling we take *X* to be 694MHz, which would be consistent with the band plan adopted by the USA, which starts at 698MHz (see Section 6.5). This enables 470–694MHz (Channels 21–48) to be used for high-power DTT, with 4MHz of separation between the core band and the second sub-band.

In Scenario 2, interference from high-power DTT in one Member State to the next would be eliminated from a significant part of the band (694–862MHz). Cross-border coordination would be significantly easier than it currently is throughout this range. With high-power DTT broadcasting limited to a core band (e.g. 470–694MHz), additional Member States could use part or (as we assume for simplicity) all of the sub-band for common services, thereby enhancing economies of scale and roaming benefits.

Member States would have to negotiate bilateral or multilateral agreements to contain high-power DTT to the core band. Clearance of the two sub-bands could result in DTT multiplexes being lost as capacity is reduced, although this could be mitigated by technological improvements. The incremental costs of clearing a second sub-band would be much more significant than with clearance of the upper sub-band, because of the larger inroads that would be made into channels currently used or planned for high-powered DTT. DTT multiplex operators who are the incumbent spectrum users in this range may resist such a change, as it would involve incremental costs in terms of network reengineering or else would force them to reduce their output. Whether it is economically efficient for these costs to be incurred depends on the value of the spectrum thereby released for other uses.

Benefits of Scenario 2

In summary, the incremental benefits of Scenario 2, compared to the Reference Scenario, are that:

- In the short term, the 790–862MHz sub-band is adopted, which accrues all the benefits discussed under Scenario 1.
- A potentially larger and more competitive wireless broadband market is permitted to develop (if supported by adequate demand), with gains in overall economic value.
- Economies of scale and roaming benefits are increased through the common deployment of wireless broadband.
- Equipment manufacturers may have greater certainty regarding investing, which would enable wireless broadband technology to be available earlier than in the Reference Scenario.
- No use is prevented in one Member State by the use of high-power DTT in another.
- There is potential for future innovation, particularly in 694–790MHz, either as an "innovation reserve" as mentioned by some Member States, or simply as spectrum available for new and as yet unknown uses.

Costs of Scenario 2

The incremental costs of Scenario 2, compared to the Reference Scenario, are:

- The reduced number of DTT programming channels in some Member States and net loss of associated economic value, and/or the cost of potentially significant upgrades to more efficient technology.
- Additional network replanning, including bilateral negotiations.
- Additional costs for repositioning or replacing aerials as a result of network replanning.

12.2.4 Scenario 3: high-power DTT is not used in the 470–862MHz band

Scenario 3 is a radical scenario. It explores an outcome where, in the short term, the 790–862MHz sub-band is still adopted in 2012, and where in the longer term (modelled as 2020 onwards), high-power transmission is *not* used in 470–862MHz band. This is a radical outcome and departs significantly from the existing situation. Therefore, this is largely a theoretical scenario, as any decision to adopt this approach is very sensitive and would require a political decision to be taken, in addition to any economic case being made.

The main benefit of this scenario is that cross-border interference would be minimised, whereas high-power DTT use essentially precludes large areas of neighbouring Member States from using similar channels (for DTT or other uses). In this scenario the entire 470–862MHz band is available in all Member States.

Clearance of the entire band for uses other than high-power DTT does not preclude lower-power DTT services being deployed in such a way as to limit harmful interference to uses in neighbouring Member States. However, for simplicity we assume that entire band is used for wireless broadband or some future new high-value use. This is reasonable given national lower-power DTT coverage is unlikely to be an economically viable proposition in most Member States. Thus, television would be accessed by a variety of other platforms such as cable, IPTV or satellite. Satellite services provide better rural coverage than terrestrial broadcasting in most Member States; hence this need not result in the loss of access to television services. In some rural households, however, satellite would be the only available platform.

In this scenario, most of interference from high-power DTT across borders would therefore not occur. Cross-border coordination would be significantly easier than at present, throughout the 470–862MHz band.[173] With DTT entirely out of the band, a very large amount of spectrum (392MHz) would be available for all the other uses, as well as potentially for new, unforeseen uses.

In order for television services to remain accessible, free to view, for the vast majority of the population, whilst protecting cross-border audiovisual rights, we have assumed that each Member State would operate its own satellite- and/or cable-based free-to-view platform. This would require potentially significant investment to develop and operate, and there would also be transition costs to replace existing TV aerials and set-top boxes.

Benefits of Scenario 3

In summary, the incremental benefits of Scenario 3, compared to the reference scenario, are:

- In the short term, the 790–862MHz sub-band is identified, accruing all the benefits discussed under Scenario 1.
- No use is prevented in one Member State by the use of high-power DTT in another, increasing the value of alternative (wireless broadband) uses.
- A large amount of spectrum is available for other uses throughout the EU, enabling the benefits of these services to be maximised.

Costs of Scenario 3

The incremental costs of Scenario 3, compared to the Reference Scenario, are:

173 There will always be a need for cross-border coordination even with lower-power uses, as is the case with cellular mobile services currently, but large areas would not be broad sterilised across borders.

- The development of free-to-view services on the satellite/cable platform as a substitute for DTT, including regional and local content.
- The costs of deploying satellite dishes or new cable connections, as well as new set-top boxes in all households that require them.
- A potential loss in consumer value from removing the DTT platform., as it may not be possible to fully replicate the consumer experience of the DTT platform on other platforms. However, this cost has not been explicitly included in our quantitative modelling.
- Potentially, reduced competition and incentives for service innovation in TV platforms. Again this cost has not been included explicitly in our quantitative modelling.

Finally, we note that realising this scenario would be politically sensitive, and that any decision to implement it would need to be a political one.

12.3 Spectrum demand scenarios

The scenarios for spectrum demand involve plausible but very different assumptions about the demand for spectrum from potential uses. These demands will vary by Member State, but the work in Section 10 suggests that many drivers will be common. The spectrum demand scenarios are used as sensitivities in estimating the relative economic impact of the different scenarios for spectrum supply already described.

In speaking of spectrum demand it is important to stress that we mean *efficient* demand for spectrum, driven by consumer demand for services and the efficient use of technology to minimise costs. Economically efficient use of the spectrum requires that it is allocated and exploited so that the total private value (consumer and producer surplus) across all uses is maximised. However, since in most Member States possession of spectrum rights carries minimal cost, operators will generally prefer more spectrum to less.

Again, in order to keep the number of scenarios to a reasonable minimum while focusing on the factors that could most affect economic outcomes, we simplify matters by assuming that uncertainty in spectrum demand is driven by uncertainty about consumer demand for services, rather than about technology and costs. This was the approach taken in Section 10. In calculating the economic impact of each combination of scenarios for spectrum supply and consumer demand, we model technology choice by assuming that operators deploy the standards and infrastructure that maximise the total (private) value that can be generated, based on currently known cost parameters. Six overall scenarios for spectrum demand are used (referred to as Scenarios A–F), which are combinations of two levels of consumer demand for DTT and three for wireless broadband and other medium-power services, as shown in Figure 12.2. Thus, for example, in Scenario A there is low demand for DTT and also low demand for wireless broadband.

		Wireless broadband		
		Low	High	High with new use
DTT	Low	Scenario A	Scenario B	Scenario C
	High	Scenario D	Scenario E	Scenario F

Figure 12.2: Demand scenarios for the 470–862MHz band [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

- **Low demand for DTT** – Consumer demand for DTT and hence the economic value generated by it is at the lower end of estimates, for example because consumers place an increasing value on non-linear and interactive services which are more suitable for other platforms (especially IPTV and cable). This case reflects a mixture of Demand Forecasts 1 and 2 described in Section 10.1, which will be specific to each Member State.

- **High demand for DTT** – Consumer demand for DTT is at the higher end of estimates; this case reflects a mixture of Demand Forecasts 2 and 3, described in Section 10.1, and likewise will be specific to each Member State.

- **Low demand for wireless broadband** – Mobile broadband fails to find a large distinct market, or to compete effectively with fixed broadband due to the lower speeds it offers. As a result, the spectrum available in the 900MHz band is sufficient to cater for a significant proportion of the demand. This case is related to Demand Forecasts 1 and 2 described in Section 10.2 and means that the incremental economic value generated by wireless broadband is at the lower end of estimates.

- **High demand for wireless broadband** – Mobile broadband is ubiquitous, and rural households demand high bandwidth from wireless broadband, effectively as a substitute for fixed broadband services which may be unavailable or inadequate. This case is similar to Demand Forecast 3 described in Section 10.2, where the economic value generated by using part of the digital dividend spectrum for wireless broadband is at the higher end of estimates.

- **High demand for wireless broadband plus a new use** – The conditions described in the high-demand case still hold, but in addition a new non-DTT use emerges that attracts significant consumer demand and requires additional spectrum. This could be an entirely new and unforeseen use, or could be an evolution of wireless broadband such as the very high-speed wireless broadband services using future technologies such as LTE Advanced as described in Demand Forecast 4 (see Section 10.2).

13 Economic value of demand and supply scenarios

In Section 12, we described a range of scenarios for the supply of and demand for digital dividend spectrum. In this section we summarise our high-level estimation of the private economic value that each spectrum supply scenario may deliver to the EU under each demand scenario. This estimation is by nature incremental, i.e. the economic value of a given demand/supply scenario combination is estimated by calculating the incremental costs and benefits over and above the Reference Scenario presented in Section 12.2.1. Our analysis focuses on the *private* value generated by each scenario, which we quantify. However, we also consider the *external* value and potential implications in our conclusions.

Section 13.1 presents our approach to modelling the economic value; Section 13.2 shows the results of the analysis; Section 13.3 provides a summary of the results and observations.

13.1 Approach to modelling the economic value of different scenarios

In order to model the economic value for each demand/supply scenario combination, the incremental benefits and costs need to be quantified; the difference between benefits and costs is the economic value. The type of incremental benefits and costs that are anticipated for each supply scenario were introduced in Section 12.2, and are summarised in Figure 13.1 below.

Incremental benefits	*Scenario 1*	*Scenario 2*	*Scenario 3*
No use prevented in the 790–862MHz sub-band in any Member State	✓	✓	✓
Increased value from economies of scale and roaming	✓	✓	✓
Greater certainty for manufacturers	✓	✓	✓
Additional benefits from spectrum beyond the 790–862MHz sub-band		✓	✓
Incremental costs	*Scenario 1*	*Scenario 2*	*Scenario 3*
Loss of DTT multiplexes	✓	✓	(✓)
Upgrade and changes to broadcasting networks	✓	✓	(✓)
Consumer switching costs – change in broadcasting networks	✓	✓	(✓)
Development of alternative free-to-view platform			✓
Consumer switching costs – alternative free-to-view platform			✓

Figure 13.1: Sources of incremental benefits and costs in supply scenarios [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

Note that in Scenario 3, high-power DTT is not used in the 470–862MHz band from 2020, we also assume that the 790–862MHz sub-band is adopted in 2013. Therefore, we include the incremental benefits and losses associated with the adoption of the sub-band until 2020. This includes the potential loss in value from removing a DTT multiplex due to the adoption of the sub-band. After 2020, we assume that high-power DTT is removed from the 470–862MHz band entirely, and that an equivalent free-to-view service is provided on other platforms and that consumers switch to these platforms. Suitable assumptions have been made in our modelling to account for the cost of creating such an alternative platform and switching consumers to it (e.g. cost of connecting households to this platform, new set-top boxes, and the logistics of organising such a switch). To simplify the modelling, we have assumed that the consumer experience is unaffected by this switch and as a result there is no loss in consumer value. We revisit this assumption in Section 13.3.

In this section we take each of the three supply scenarios and explain how the relevant benefits and costs are quantified. Note that the level of costs and benefits considered throughout this analysis are by nature uncertain. Where this uncertainty is substantial, such as that surrounding wireless broadband, we have therefore designed the demand and supply scenarios to cover a wide range of possible situations.

13.1.1 Scenario 1: high-power DTT is used in 470–790MHz, and a 790–862MHz sub-band is adopted for a common use

As shown in Figure 13.1, there are three groups of benefit and three costs identified for Scenario 1; below we explain our approach to quantifying each.

Benefit: no use is prevented in the 790–862MHz sub-band in any Member State

In order to quantify the situation in which no use is prevented in one Member State by the use of high-power DTT in the same frequency range in another, we have assumed that wireless broadband is deployed in all Member States in the 790–862MHz sub-band (in the Reference Scenario high-power DTT uses the whole sub-band). This assumption yields a number of incremental benefits.

- Member States which use the sub-band for wireless broadband in the Reference Scenario benefit from there being no significant interference from neighbouring Member States. This means that more people can get access to the service, particularly in rural areas where there is limited wireless broadband coverage from other spectrum bands (e.g. 2.1GHz, 2.6GHz). This benefit is assumed to be realised from the beginning of 2013, the earliest date when the sub-band is likely to be adopted in most Member States.

- There are also incremental benefits to some Member States of using wireless broadband in the sub-band where it would have been used for high-power DTT. We have assumed this benefit will be realised from 2015, given that many Member States border non-EU countries, which are unlikely to adopt the sub-band before 2015.

These benefits are illustrated in Figure 13.2 below.

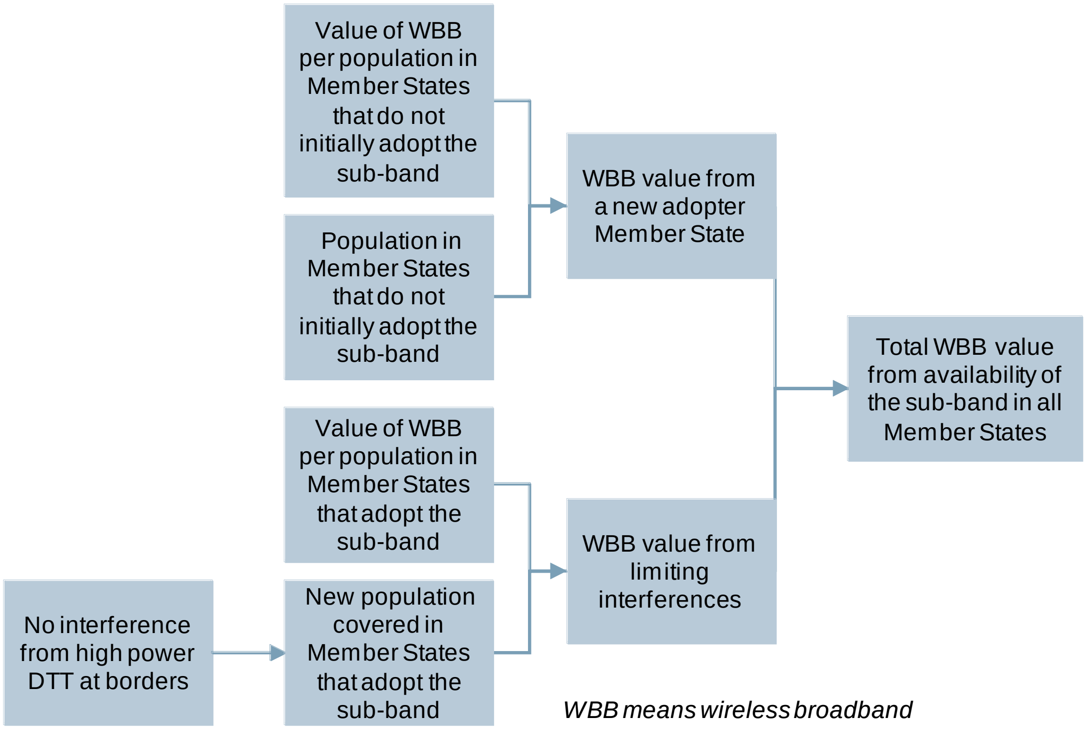

Figure 13.2: Calculation flow to generate the total value associated with wireless broadband in Scenario 1 [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

One key input into our calculation is the total area of those Member States that is sterilised by high-power DTT broadcasting in neighbouring countries. Determining this accurately requires a detailed knowledge of the location and transmission power of every DTT site in the EU and its neighbouring countries, as well as lengthy analysis using propagation simulation tools. However, given the high-level nature of our economic analysis, such detail is not required. Instead we have calculated the buffer areas around each country that we assume will not adopt the sub-band (we have calculated this for 50km, 100km and 150km buffers). This approach is illustrated in Figure 13.3 below for 100km, assumed in the results below, which we believe to be a reasonable estimate for the average sterilisation distance, though we note that this distance may vary significantly depending on local geography.

Figure 13.3: *Assumption of regions in which harmful interference is caused by countries using the 790–862MHz sub-band for high-power DTT (in the Reference Scenario) [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]*

The other significant input is the estimated value of wireless broadband in areas newly covered. We have used a value per person extrapolated from the studies described in Section 9, adjusted in the following ways:

- 900MHz spectrum will be available for wireless broadband services, we therefore reduced the value calculated in studies where the assumption was that 900MHz would *not* be used for wireless broadband
- the existing studies vary in their assumption regarding the launch date of wireless broadband in the sub-band, we adjusted their results to reflect a launch at the beginning of 2013

- we adjusted the existing studies results to a 15-year valuation period, excluding any terminal value.

The resulting range is a 15-year net present value of between EUR127 and EUR312 per person from the use of wireless broadband in the sub-band. In the low-demand scenarios for wireless broadband (A and D), we have used the lower bound of this range, whereas for the high-demand scenarios (B, C, E and F) we have used the higher bound.

Note that these studies include various sources of incremental private value generated by wireless broadband using digital dividend spectrum, including increased capacity and the ability to provide wireless broadband coverage in rural areas. This may include benefits from increased competition from there being multiple providers of wireless broadband, particularly in rural areas.

Benefit: increased value from economies of scale and roaming

In order to quantify the benefit generated by economies of scale and roaming benefits, we have assumed that wireless broadband is deployed in all Member States in the 790–862MHz sub-band, using common technologies and a common band plan. This yields the following incremental benefits.

- Handsets and network equipment manufacturers will have access to a larger market and will benefit from economies of scale as more Member States use the sub-band for wireless broadband. Our calculation flow for this benefit is illustrated in Figure 13.4 below.

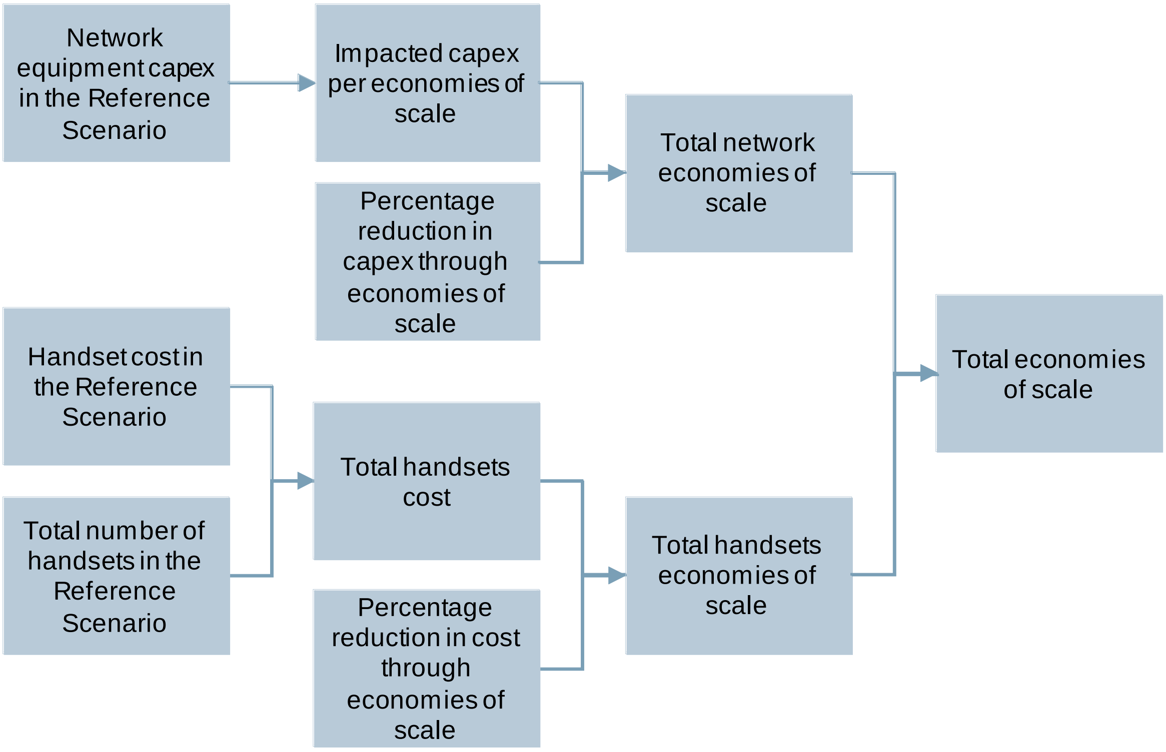

Figure 13.4: Calculation flow to generate the value of economies of scale in Scenario 1 [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

The value that consumers gain from wireless broadband will be increased as they will be able to roam in larger areas. Our calculation flow for this benefit is illustrated in Figure 13.5 below.

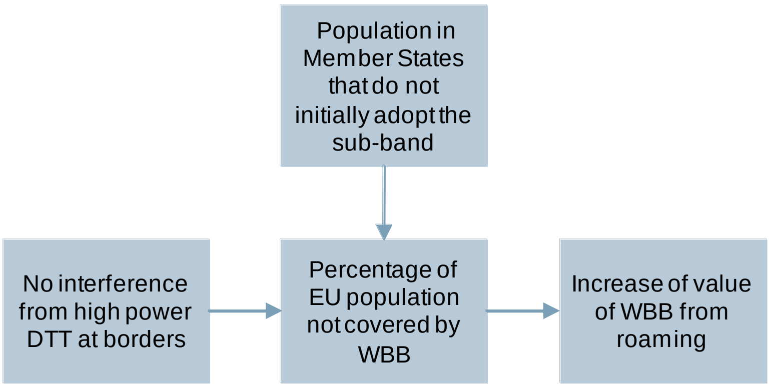

Figure 13.5: Calculation flow to generate the value of increased roaming benefits in Scenario 1 [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

We have estimated the economies of scale that can be achieved using historical data on the relationship between GSM equipment unit costs and number of GSM subscribers in Europe. This data has come from a number of sources, including mobile cost models published by SMAs. We estimate that the increase in demand from the sub-band being adopted throughout the EU would result in the cost of network elements being reduced by 1.5%. We have assumed a similar reduction in unit costs for handsets.

Note that we have applied these benefits solely to the Member States that we assume will adopt the sub-band in the Reference Scenario. For the other Member States we assume that the estimated values for wireless broadband in existing studies take account of economies of scale.

Benefit: greater certainty to manufacturers

If more Member States commit in the near future to adopting the 790–862MHz sub-band, manufacturers will be more certain that there will be a large market for their products. This could reduce the product development time and bring equipment to market faster, thus bringing forward the value generated by wireless broadband.

Figure 13.6 below illustrates the calculation flow we have used for this benefit.

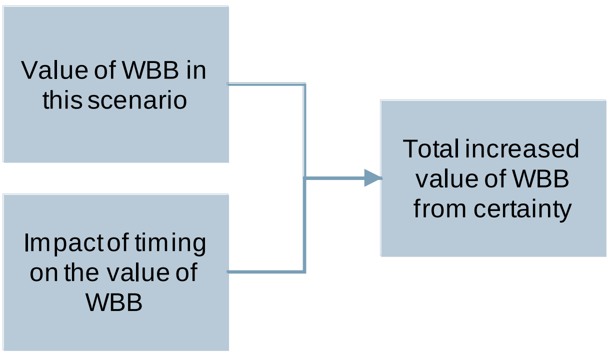

Figure 13.6: Calculation flow to generate the value of wireless broadband associated with gain in certainty for equipment manufacturers in Scenario 1 [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

In order to quantify this benefit, we have used figures from those studies that quantified the impact of a delay in the availability of the sub-band for wireless broadband services. We have assumed that an EU-wide commitment to the sub-band would bring forward the service launch by one year. This increases the total value generated by adopting sub-band by approximately 10%. This benefit applies to all Member States, not only those that do not adopt the sub-band in the Reference Scenario.

Cost: loss of DTT multiplexes

The costs associated with losing DTT multiplexes, and therefore TV programming channels, are illustrated in the flow-chart in Figure 13.7 below.

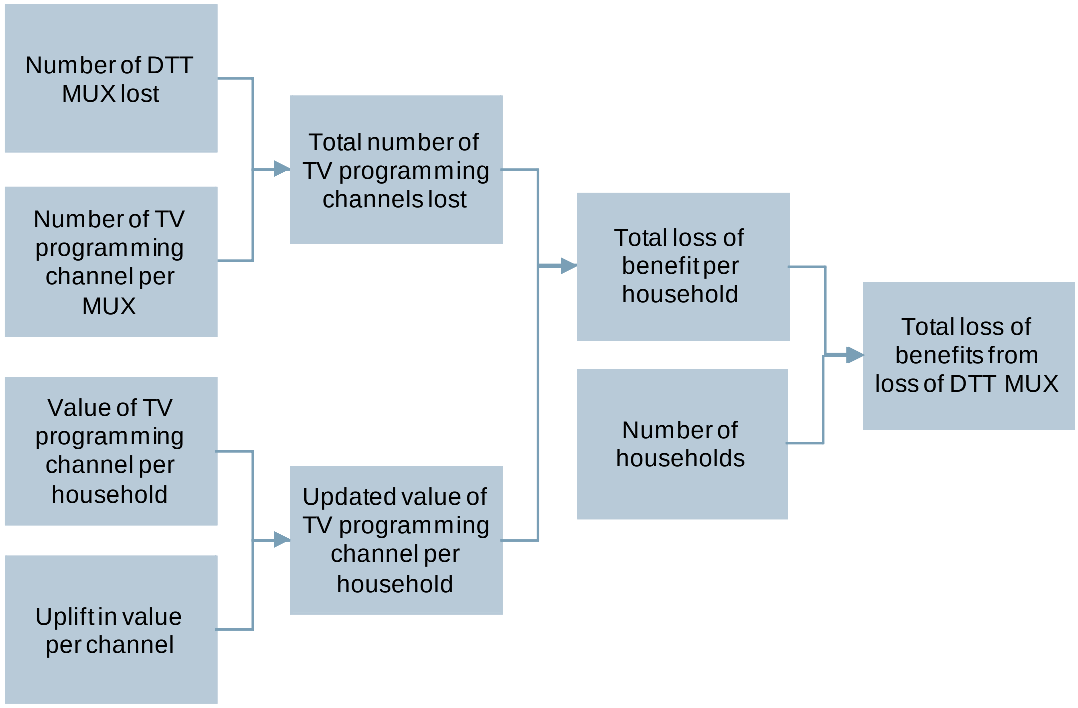

Figure 13.7: Calculation flow of costs associated with the loss of one or two DTT multiplexes in Scenario 1 [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

These costs are very dependent on the number of TV programming channels available prior to any DTT multiplex loss, and the value that consumers place on those TV programming channels that would be lost. In order to quantify this, we have made several assumptions.

- For Member States where MPEG-2 is used[174], (see Figure 4.6) five TV programming channels are available on average on each multiplex. This is an average across all Member States, and reflects an average mix of standard definition (SD) and high definition (HD) TV programming channels (note that a multiplex using MPEG-2 could offer up to eight SDTV programming channels).
- For Member States where MPEG-4 is already used[175], or is expected to be used, we assume the average number of TV programming channels per multiplex to be six, reflecting a higher proportion of HD, compared to MPEG-2 multiplexes.
- The incremental value per channel is assumed to follow the curve used by ARCEP for its digital dividend valuation[176] (see Figure 13.8 below), which was based on study by DTI for the

174 We also assume that these networks adopt an MFN topology and use DVB-T.

175 We also assume that these networks adopt an MFN topology and use DVB-T.

176 Analysys Mason and Hogan & Hartson for ARCEP (2008), "Valorisation du dividende numérique".

Ofcom.[177] In the high demand for DTT scenarios (D, E and F), we have assumed the incremental value per channel to be double that in the low-value cases.

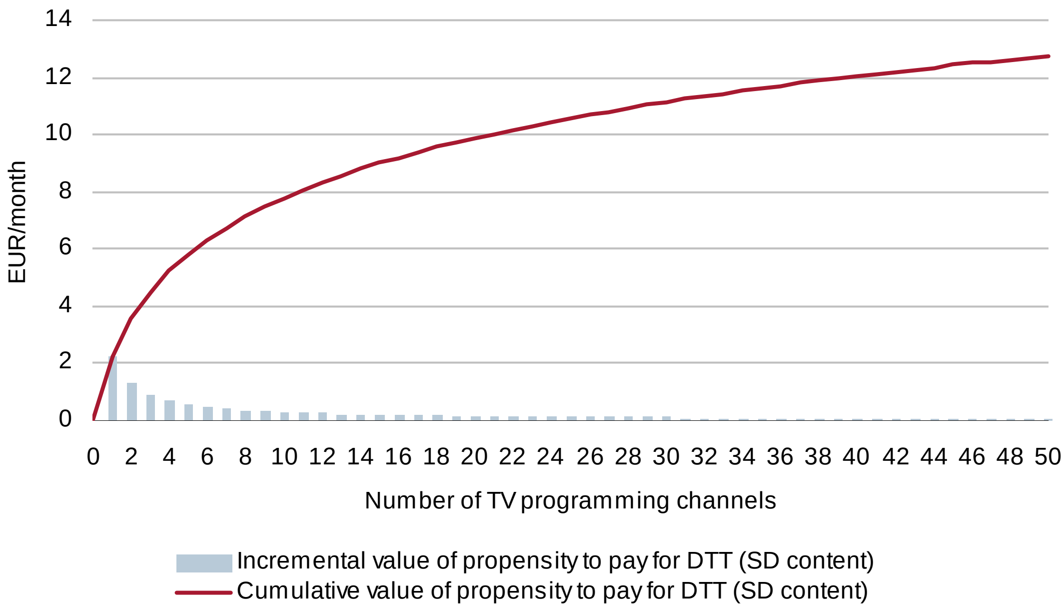

Figure 13.8: Incremental and cumulative propensity to pay for DTT [Source: ARCEP]

This loss of value is included in our modelling if spectrum available to DTT is reduced as a result of the adoption of a first and/or second sub-band. Note that we do not apply any *additional* loss of value in the case the entire band is cleared of DTT (Scenario 3), as our modelling uses the assumption that private value benefits are replicated by free-to-view services on other platforms. In addition, our modelling does not consider any potential economic loss from reduced infrastructure competition in the TV market due to the reduced offering by DTT.

Cost: network costs of technology/topology upgrades

Figure 13.9 below shows the calculation flow we used to estimate the costs associated with upgrading and replanning the broadcasting network.

177 DTI (November 2004), "Stated and revealed preference survey of digital television services".

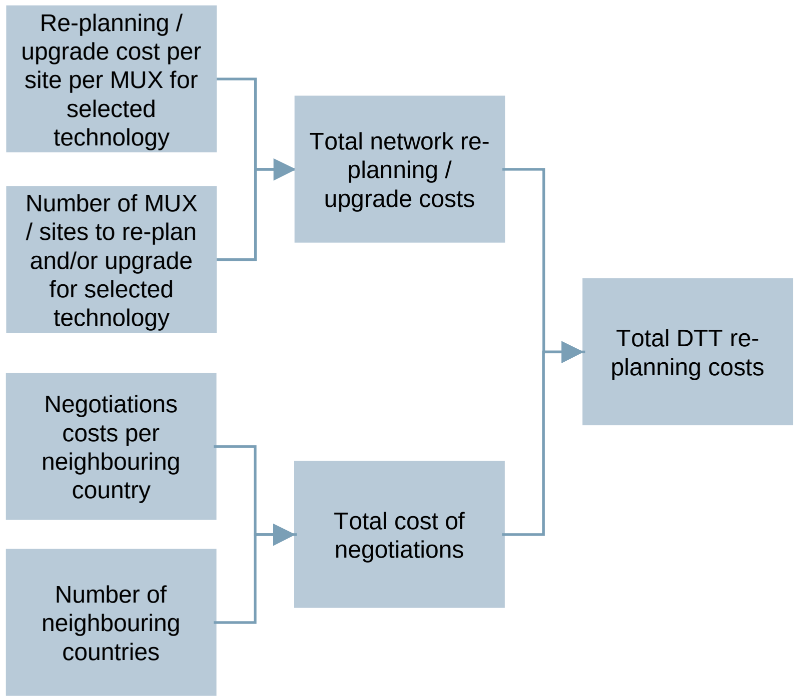

Figure 13.9: Calculation flow of costs to the broadcasters associated with DTT network replanning in Scenario 1 [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

Each network upgrade is considered to be incremental, i.e. the upgrade to DVB-T2 automatically assumes an upgrade to MPEG-4, and the upgrade to SFN automatically assumes upgrades to MPEG-4 and DVB-T2.

There are four costs captured in this model.

- *Network replanning costs*: we have assumed costs of EUR20 000 per multiplex per site for each change to the frequency use. This is applied irrespective of whether an upgrade is required or not, given that any of the supply scenarios, including Scenario 1, will entail the use of different frequency channels at various locations compared to the Reference Scenario.

- *Network upgrade costs*: we have estimated these to be on average EUR220 000 per multiplex for an upgrade from MPEG-2 to MPEG-4, and EUR300 000 per multiplex for an upgrade from DVB-T to DVB-T2. In addition, EUR10 000 per site has been assumed for upgrading of the radio equipment for any of the upgrades.

- *Deployment of new sites*: this is only required for the migration to SFNs. We have estimated that, given the concurrent deployment of DVB-T2, the number of sites required would be double the number for an MFN. We have assumed an average upfront deployment cost of EUR100 000 per new site and we have incorporated additional opex of EUR12 000 per site per multiplex for each new site deployed.

- *Cost of bilateral negotiations between neighbouring countries*: significant manpower would be required to carry out renegotiations of spectrum allocations between two neighbouring countries, or indeed for the purpose of a large conference, such as GE-06. We have assumed that each negotiation (between two countries) would cost EUR1.5 million in total.

These costs are also considered in Scenario 2, for the purpose of clearing the second sub-band by 2018.

Cost: incremental consumer costs due to network upgrades

In addition to network costs, upgrading DTT networks would also result in incremental costs to consumers. These are essentially related to repositioning aerials and replacing set-top boxes as illustrated in Figure 13.10.

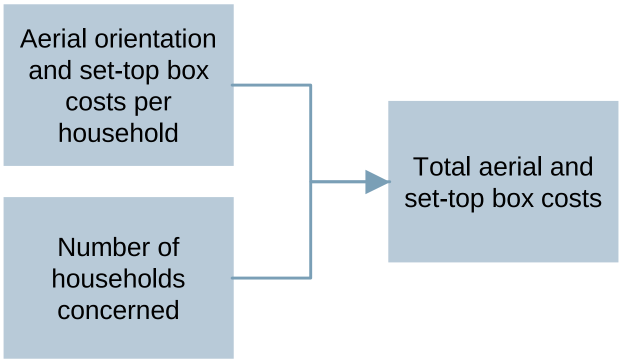

Figure 13.10: Calculation flow of costs to consumers associated with DTT network replanning in Scenario 1 [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

We have assumed the following specific costs.

- *Aerial upgrade/repositioning*: even if the network is not upgraded, changes in DTT frequency assignments may require some households to re-orientate their aerials. We have assumed that this is only the case for 15% of households, at a cost of EUR130 per household. In the event of an upgrade to DVB-T2, this proportion increases to 25%, and to 40% if the network is upgraded to an SFN.

- *Set-top box upgrades*: this cost is incurred if DTT networks are upgrade to either MPEG-4 or DVB-T2. For an MPEG-4 upgrade we have assumed the gross cost would be about EUR30 per TV set using DTT (i.e. not cable, satellite or IPTV; note that this takes into account multiple TV sets). For a DVB-T2 upgrade we have assumed the cost to be EUR50 per TV set using DTT.

Cost: balancing the loss of DTT multiplexes with network upgrades

If the sub-band were adopted throughout the EU, those Member States that we assume would not otherwise adopt the sub-band (as per the Reference Scenario) would need to reduce the amount of spectrum that is made available for DTT. For Scenario 1, we assume that Member States adopting the sub-band would lose one DTT multiplex.[178] This would have one of two consequences: either the number of DTT programming channels would need to be reduced (resulting in a loss of consumer benefit), or several of the DTT networks would need to be upgraded to more spectrally efficient transmission technologies (MPEG-4 and/or DVB-T2) or spectrally efficient transmission topologies (e.g. SFNs) in order to avoid a reduction in the number of DTT programming channels. In our modelling we have calculated the cost of each, and then assumed that Member States would choose the option that minimises the loss of value (through lost consumer value or incremental network costs). This approach is illustrated in Figure 13.11.

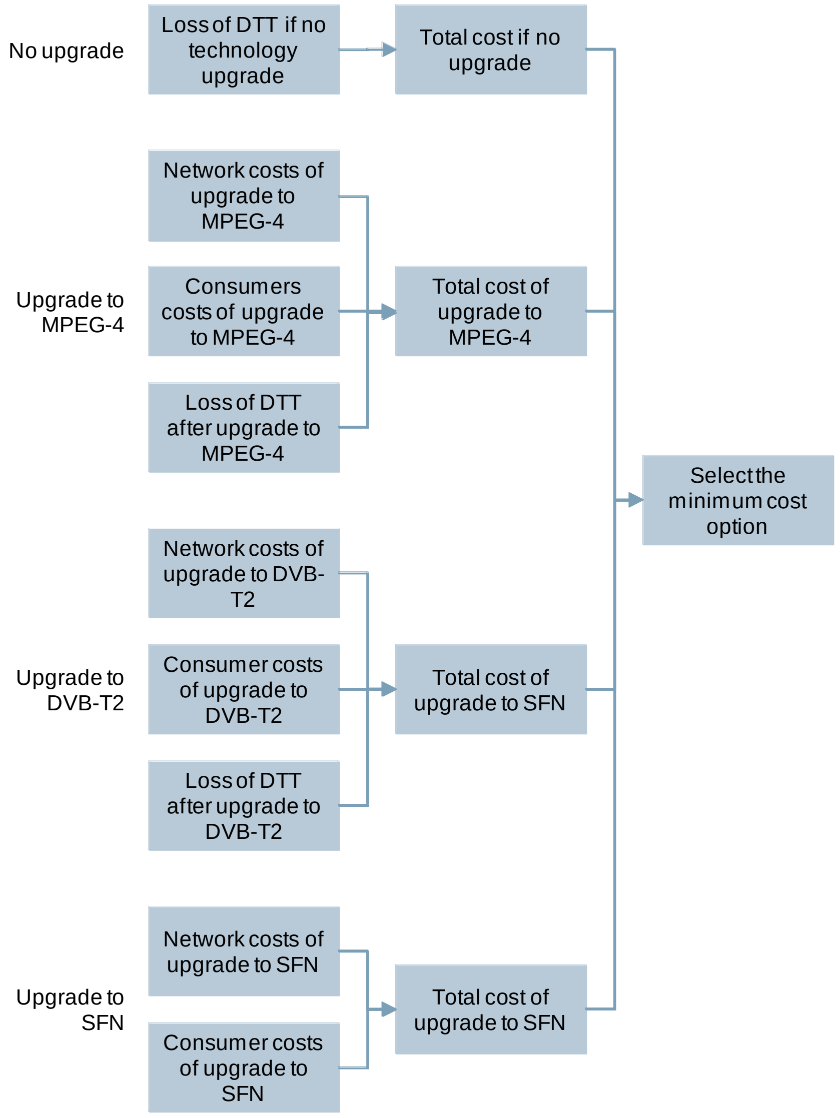

Figure 13.11: Cost calculation showing options for technology upgrade to mitigate loss of a DTT multiplex [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

178 Note that this depends on the number of multiplexes that each Member State was planning to create based on GE-06 allocations; we have assumed an average number, which would be six national multiplexes if no sub-band is adopted, five if the 790–862MHz sub-band is adopted, and three if two sub-bands are created between 694–862MHz.

For Scenario 1, our results suggest that the economic value would be maximised if those Member States that currently using MPEG-2 upgraded to MPEG-4, rather than reduce the number of TV programming channels. For Member States that already use/plan to use MPEG-4, we calculated that the economic value would be maximised if they reduced the number of TV programming channels rather than upgrading to DVB-T2 or SFNs, under both low-value and high-value DTT demand scenarios. The loss of TV programming channels may result in a loss of external value as well, which is not explicitly considered in this quantitative assessment but is discussed further in Section 13.3.

13.1.2 Scenario 2: high-power DTT is used in a core band, and two sub-bands are identified

The incremental benefits and costs that are anticipated in Scenario 2 are introduced in Section 12.2.3. Below we outline the approach we have taken to quantifying these.

Benefits associated with the 790–862MHz sub-band

There are four benefits related Scenario 2, of which three benefits are in common with Scenario 1, so the same descriptions and values apply:

- no use is prevented in one Member State by the use of high-power DTT in another
- economies of scale and roaming benefits are maximised in the 790–862MHz sub-band
- equipment manufacturers may have greater certainty, which would encourage investment thereby enabling wireless broadband technology to be available earlier than in the Reference Scenario.

For Scenario 2, a second sub-band becomes available from 2018, which generates other incremental benefits. For the purpose of this modelling, we have assumed that this would represent 92MHz of spectrum (694–790MHz excluding the 4MHz guard band).

Benefit: additional benefits from spectrum beyond the 790–862MHz sub-band

In the low and high wireless broadband demand scenarios (A, B, D, E), we assume that the second sub-band is used for wireless broadband. Based on existing studies, we have estimated this additional benefit to be in the order of 20% of the benefit of the first sub-band.

In Scenarios C and F (high-value with new use), we assume the second sub-band will be used by the new high-value use, generating a higher incremental economic value if were to be used by wireless broadband. We have assumed the value of such a use to be EUR64 billion (EUR45 billion in net present value), equivalent to the lower estimate of the total incremental value to the EU of wireless broadband in the 790–862MHz sub-band.[179]

Costs associated with the 790–862MHz sub-band

The following incremental costs are applicable under Scenario 2, in exactly the same way and magnitude as described for Scenario 1:

- loss of multiplexes in all Member States, or potentially significant upgrades to more efficient technology
- additional network replanning including bilateral negotiations
- additional costs for repositioning or replacing aerials as a result of network replanning.

Cost: additional costs to constrain DTT below the second sub-band

In order to adopt both the first and the second sub-bands we assume that an *additional* two DTT multiplexes would be lost (i.e. three multiplexes would be lost in total). Applying the same approach as that described in Section 13.1.1, we have identified that upgrading to an SFN is likely to be required to maximise value in Scenario 2, under both the low-value and high-value DTT demand scenarios. This would also mitigate any loss of external value that may result from losing TV programming channels.

13.1.3 Scenario 3: high-power DTT is not used in the 470–862MHz band

The incremental benefits and costs that can be expected under this radical scenario are introduced in Section 12.2.4. In this section we outline the approach we have taken to quantify these.

Benefits associated with the 790–862MHz sub-band

The following incremental benefits are applicable to this scenario in exactly the same way and magnitude as described for Scenario 1:

- no use is prevented in one Member State by the use of high-power DTT in another
- economies of scale and roaming benefits maximised in the 790–862MHz sub-band
- equipment manufacturers may have greater certainty regarding investing, which would enable wireless broadband technology to be available earlier than in the Reference Scenario.

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179 EUR64 billion is calculated by EUR127 per person multiplied by the total population of the EU.

Benefit: additional benefits from spectrum beyond the 790–862MHz sub-band

In Scenario 3, the remainder of the 470–790MHz band becomes available from 2020. This makes available a large amount of spectrum for new or existing uses.

In both the low and high wireless broadband demand scenarios, we assume that this spectrum is used for wireless broadband. Existing studies have considered an extension of around 130MHz to the initial 790–862MHz sub-band, which we have estimated to be approximately 20–25% of the benefit of the first sub-band, marginally higher than in Scenario 2.

In Scenarios C and F, we have assumed that the spectrum can be used both by more wireless broadband, generating the benefit described above, as well as a new high-value use. This is a substantial benefit as it would affect all Member States. This benefit is modelled in the same way as Scenario 2, as described in Section 13.1.2 above.

Costs associated with the 790–862MHz sub-band

The following incremental costs are also applicable to this scenario, as described for Scenario 1:

- loss of multiplexes in all Member States, or potentially significant upgrades to more efficient technology
- additional network replanning including bilateral negotiations
- additional costs for repositioning or replacing aerials as a result of network replanning.

Cost: development of an alternative free-to-view platform

Should a political decision be taken to adopt this scenario, in order to create a replacement for the DTT platform, we have assumed that each Member State would develop a free-to-view satellite platform that could be accessed universally. This implies a number of costs illustrated in the flow-chart in Figure 13.12 below.

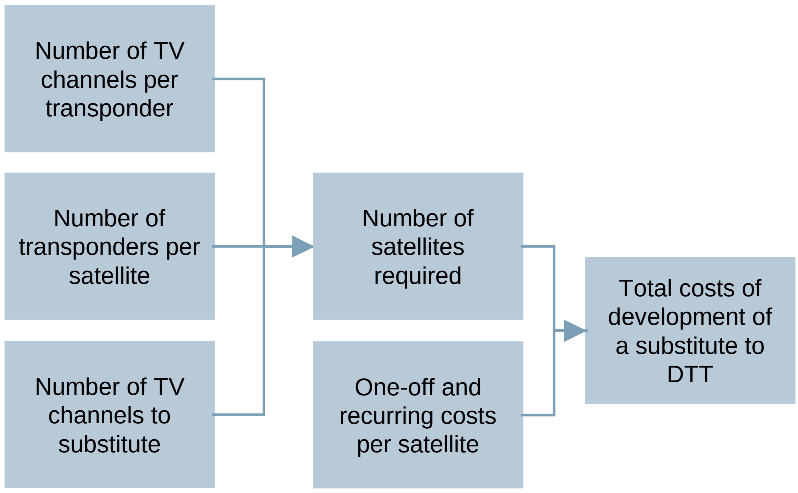

Figure 13.12: Calculation flow of costs associated with the development of an alternative free-to-view platform in Scenario 3 [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

The costs of developing a platform are relatively modest, based on those of ITV and the BBC in the UK in developing the Freesat service. There will, however, be a requirement for conditional access systems, particularly in order to protect national copyrights as satellite signals will inevitably cross national borders.

The second, and much larger cost, relates to the requirement to create sufficient capacity on the satellite platform in order to accommodate a free-to-view service. We have assumed that each Member State would require the capacity of six transponders, meaning that each satellite would be able to serve between three and four Member States. We have also assumed that about 25% of Member States already have sufficient satellite capacity, leaving 75% needing to launch satellites. This is a complex and costly endeavour, which can be expected to cost several billion Euros. There are important practical challenges too, such as finding the right time slot to launch the required satellites and identifying space over Europe for geostationary orbit.

Even discounted from 2020, the present value of the costs of developing such a system can be expected to be EUR7.5 billion.

Cost: the cost of switching from DTT to free-to-view satellite

If a political decision was taken to adopt this scenario, in addition to the platform costs outlined above, there will be costs for consumers to switch from DTT to the alternative platform. In our modelling, we have considered the costs of new set-top boxes in all households that require it, including for secondary TV sets, as well as the installation of satellite dishes where required. Our calculation flow for these costs is illustrated in Figure 13.13 below.

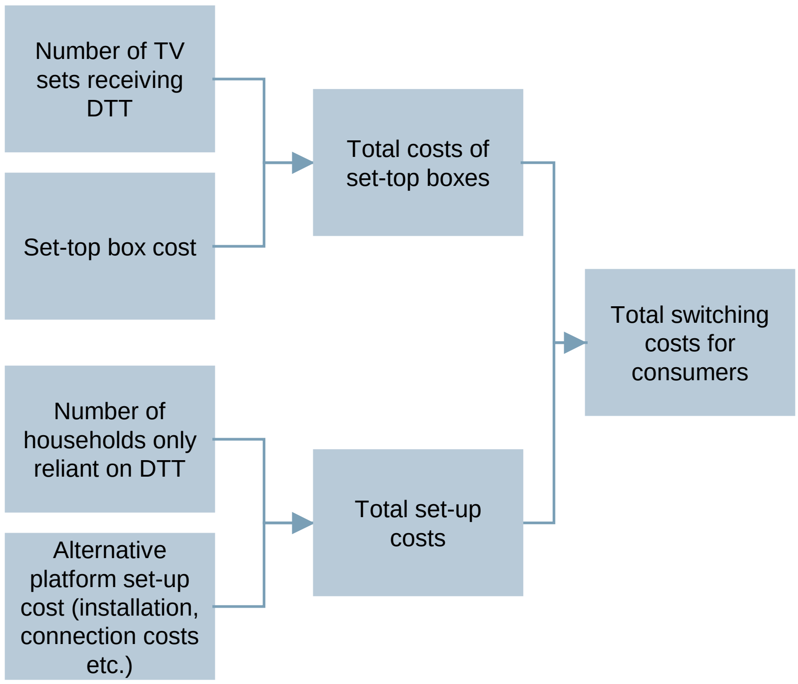

Figure 13.13: Calculation flow of consumers' switching costs in Scenario 3 [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

We have assumed that these costs include the following:

- *Alternative platform set-up cost*: we have assumed that all households that use DTT will need to replace their DTT aerial with alternative equipment, such as a satellite dish, at a cost of EUR130 per household for installation plus EUR30 for the dish. We have assumed, in addition, a EUR100 cost per household to reflect the general cost of the logistics involved in replacing DTT by an alternative platform (e.g. marketing).
- *Set-top box upgrade:* this will be required for each TV set used to watch DTT (either primary or secondary sets). We have assumed the cost of these set-top boxes to be EUR30.

In total, we estimate the costs to consumers of turning off the DTT platform and switching to the satellite platform to be over EUR38 billion (EUR24 billion in present value).

As in the other scenarios, we have not included any economic loss from reduced platform competition in the TV market due to the removal of the DTT platform. It should be noted that the reduction in competition could be significant in some areas, notably in rural areas where satellite may be the only platform available. In such circumstances we assume that the prices offered by satellite provides would be regulated if necessary. For the avoidance of doubt, the cost of regulation has not been included in the modelling.

13.2 Results of the economic analysis

This section provides our estimates for the incremental value generated by each supply scenario, under each demand scenario. The results focus on *private* value, for which quantitative results are given, however we also consider the *external* value impact of each scenario in our conclusions. A summary of the results is given in Section 13.3 below.

13.2.1 Scenario A: low DTT demand, low wireless broadband demand

Shown below are the incremental costs and benefits of each of the three supply scenarios under demand Scenario A where there is low DTT demand (DTT is moderately valuable at the margin) and low wireless broadband demand (the value of wireless broadband is at the lower end of the estimates from existing studies). (See Figure 13.14, Figure 13.15 and Figure 13.16).

Under Scenario 1 (the results for which are illustrated in Figure 13.14 below), Member States that would have retained DTT across the entire 790–862MHz sub-band in the Reference Scenario, but now adopt the 790–862MHz sub-band under Scenario 1, experience a significant benefit from wireless broadband. This benefit outweighs the costs associated with the adoption of the sub-band (DTT frequency replanning and the loss of a DTT multiplex). We calculate that in order to maximise the economic benefit these Member States should adopt MPEG-4 as the DTT broadcasting technology. This can be done at a relatively low cost to broadcasters, and significantly reduces the loss of TV programming channels and thus benefits consumers.

Compared to the Reference Scenario, sizable benefits accrue to Member States as use of the sub-band is not sterilised in large areas, plus there are economies of scale and more certainty for manufacturers.

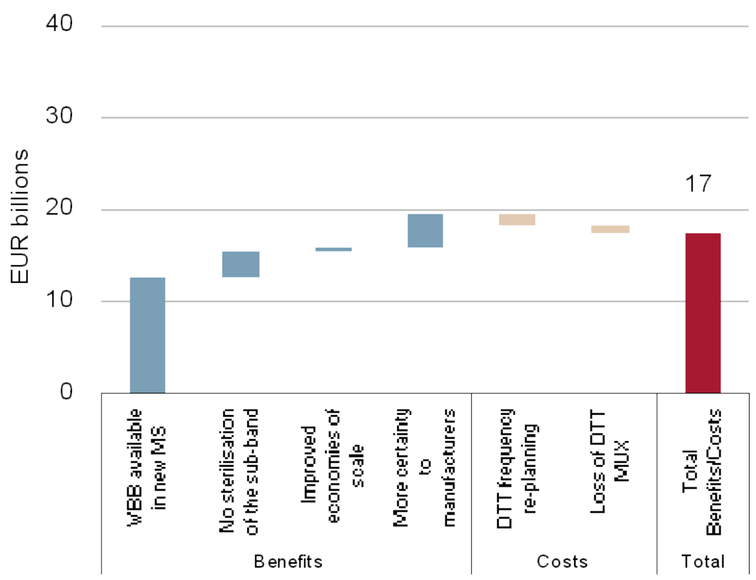

Figure 13.14: Incremental value of Scenario 1 under Scenario A [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

Under Scenario 2 (the results for which are illustrated in Figure 13.15 below) there are also benefits from the first sub-band. From 2018, a second sub-band is adopted in order to allow wireless broadband to use more spectrum, which has two consequences.

Firstly, the additional spectrum available to wireless broadband enables a mixture of additional competition (more operators) and higher-value services (for instance faster broadband) to be delivered to wireless broadband users. Therefore, although the benefit of this second sub-band is much lower than the first sub-band, the total incremental benefit versus the Reference Scenario is comparable to the first sub-band as it is accrued by all Member States.

Secondly, DTT use from this second sub-band must be cleared, which significantly constrains the spectrum available to DTT. In Scenario 2, it is most beneficial for all Member States to upgrade their DTT networks to MPEG-4, DVB-T2 and SFNs. As in Scenario 1, if this upgrade were not to happen, or if less extensive upgrades were made (i.e. to just MPEG-4 and/or DVB-T2), a substantial number of TV programming channels may be lost, resulting in a large loss in consumer surplus.

In Scenario 2, the second sub-band delivers a benefit that is lower than the additional cost of clearing the second sub-band. Overall there is a net benefit compared to the Reference Scenario, but is smaller than in Scenario 1.

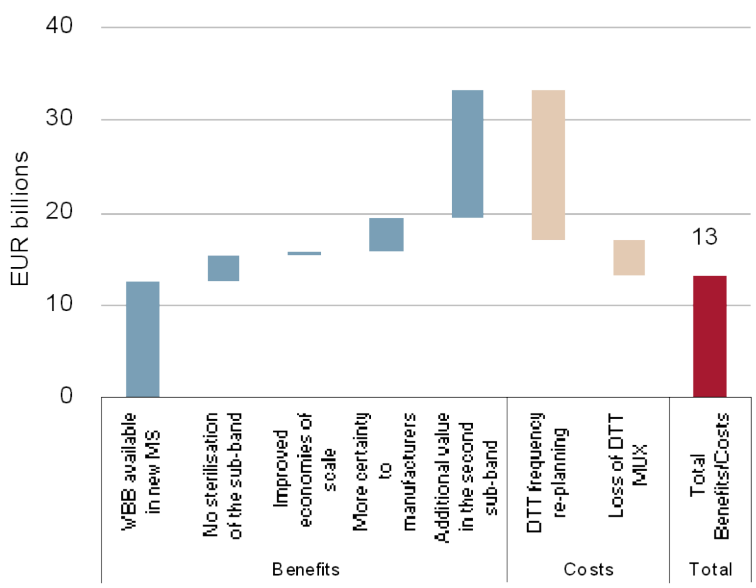

Figure 13.15: Incremental value of Scenario 2 under Scenario A [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

In Scenario 3 (the results for which are illustrated in Figure 13.16 below) the benefits of the first sub-band are also applicable until 2020. As the first sub-band is implemented, there is a loss of consumer surplus due to the loss of DTT programming channels, in the same magnitude as in Scenarios 1 and 2. Under this scenario, we have assumed that from 2020 the whole band is cleared and a universal free-to-view satellite and cable service is deployed, at significant costs to both broadcasters and consumers. As under these demand assumptions wireless broadband generates modest incremental value from access to spectrum beneath the second sub-band, the net incremental benefit that can be achieved under this supply scenario is lower that both Scenarios 1 and 2.

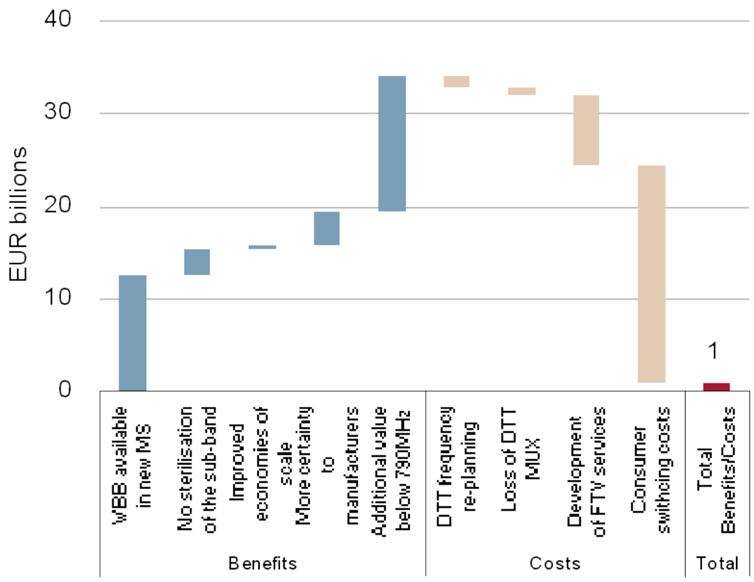

Figure 13.16: Incremental value of Scenario 3 under Scenario A [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

In conclusion, under these demand assumptions, our results suggest that adopting a 790–862MHz sub-band throughout the EU would be beneficial. Due to the relatively low value of wireless broadband, and the fact that we have not considered any new high-value use, clearing additional spectrum is unlikely to yield sufficient benefits to warrant the additional cost of constraining DTT to a smaller core spectrum band, or indeed to clear the band entirely.

13.2.2 Scenario B: low DTT demand, high wireless broadband demand

The three figures below show the incremental costs and benefits of each supply scenario under Scenario B where there is low DTT demand (DTT is moderately valuable at the margin), but high wireless broadband demand (where the value of wireless broadband is at the higher end of the estimates from existing studies). (See Figure 13.17, Figure 13.18 and Figure 13.19).

Under Scenario 1, the majority of the value is accrued by making the 790–862MHz sub-band available for wireless broadband in all Member States. This value is significantly higher than under Scenario A. In order to clear the sub-band for wireless broadband, we calculate that DTT networks would upgrade to MPEG-4 (and possibly DVB-T2) rather than offer a lower number of TV programming channels.

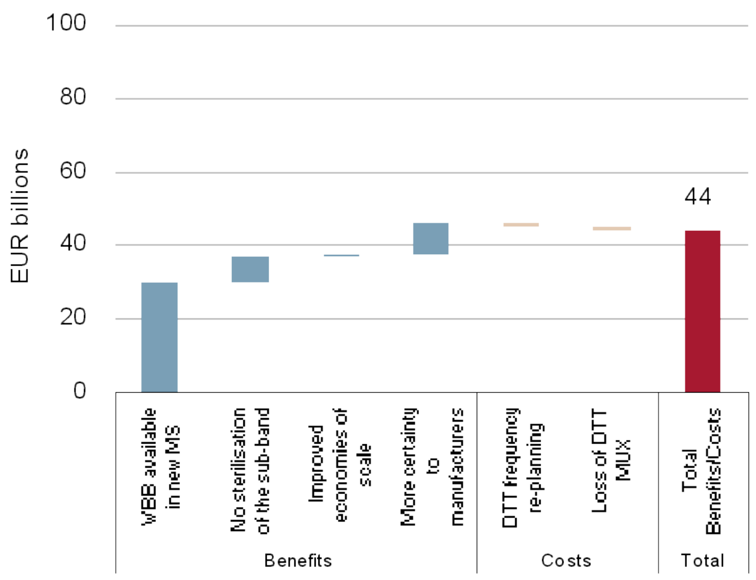

Figure 13.17: Incremental value of Scenario 1 under Scenario B [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

In Scenario 2, the high value assumed for wireless broadband also increases the incremental value that can be achieved by dedicating the second sub-band to this use. As a result, the additional value adopted in the sub-band is significantly higher than for Scenario A. This leads to an incremental value for Scenario 2 that exceeds the value of Scenario 1.

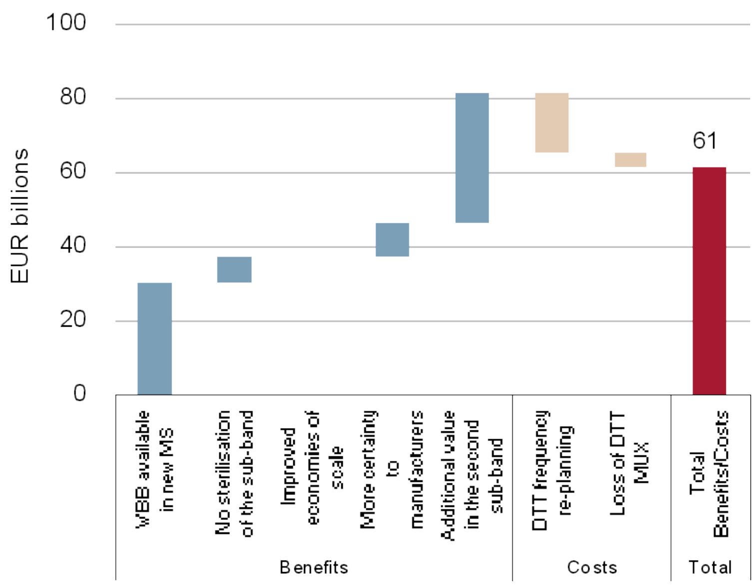

Figure 13.18: Incremental value of Scenario 2 under Scenario B [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

In Scenario 3, as in Scenario 2, the additional spectrum available to wireless broadband enables this use to generate significant value. However, the costs of setting up the free-to-view platform and switching consumers to this platform in order to clear the whole band of high-power DTT is higher than the upgrade costs in Scenario 2, which results in a slightly lower incremental value overall.

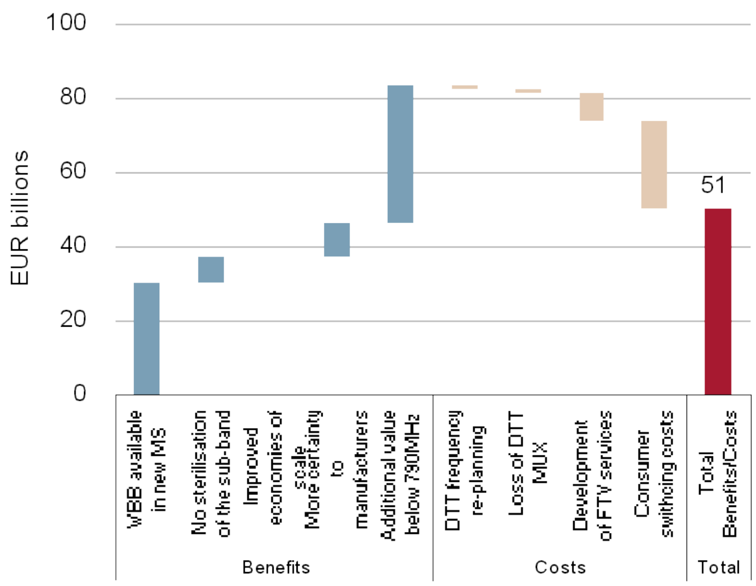

Figure 13.19: Incremental value of Scenario 3 under Scenario B [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

In conclusion, under Scenario B, where the economic value of DTT is low but where wireless broadband can deliver a high economic value, our results suggest that clearing a second sub-band beyond the 790–862MHz spectrum has the potential to create additional economic value. Clearing the whole band does not seem attractive as the value generated is lower than if just the second sub-band is adopted.

13.2.3 Scenario C: low DTT demand, high wireless broadband demand and additional uses

The three figures below show the incremental costs and benefits in each supply scenario under Scenario C, where there is low DTT demand (where DTT is moderately valuable at the margin), but high wireless broadband demand (the value of wireless broadband is at the higher end of the estimates from existing studies), and there is a new as yet unknown use, which could deliver a significant value. This new use is assumed to deliver approximately of EUR45 billion in net present value across the EU should sufficient spectrum be made available, which is similar to the lower bound of the wireless broadband value estimates. (See Figure 13.20, Figure 13.21 and Figure 13.22).

In Scenario 1, the incremental value realised is identical Scenario B, as there is no additional spectrum freed up beyond the 790–862MHz sub-band and the high-value potential new use modelled in this demand scenario cannot therefore be deployed, and does not generate additional value.

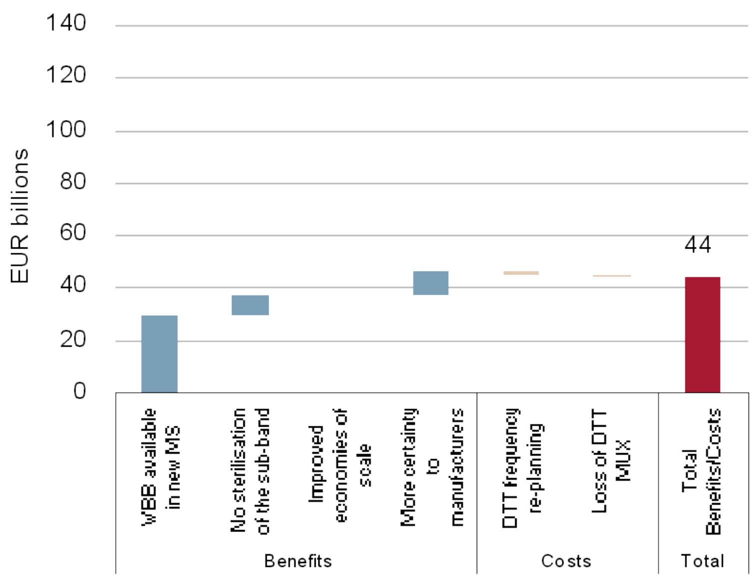

Figure 13.20: Incremental value of Scenario 1 under Scenario C [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

Under Scenario 2, however, there is additional spectrum, beyond the 790–862MHz sub-band, available from 2018. This enables the new use to be deployed, which creates a significant amount of value in the future. In this case, wireless broadband is constrained to the first sub-band as the second one is taken up by the new high-value use (which could be a different form of wireless broadband, as discussed above).

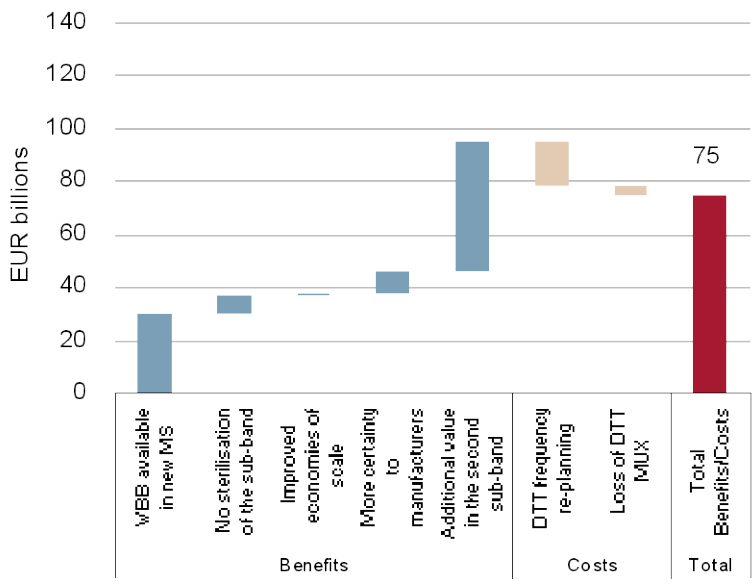

Figure 13.21: Incremental value of Scenario 2 under Scenario C [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

Finally in Scenario 3, the band clearance in 2020 enables spectrum to be allocated to both wireless broadband and to the new high-value use, generating a large incremental value.

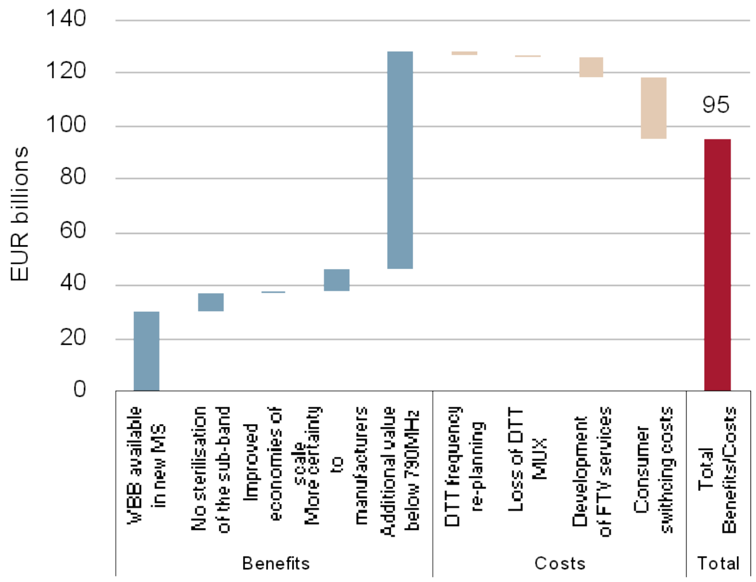

Figure 13.22: Incremental value of Scenario 3 under Scenario C [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

In conclusion, it appears that the economic costs of clearing the band, albeit sizable, could be exceeded should a new use appear, with a value similar to the low estimate for wireless broadband. However, as mentioned above, we have assumed that there is no loss in consumer value from the switch to an alternative platform and that there is no loss from reduced platform competition.

(Note the small loss shown in Figure 13.22 is due to the loss of a DTT multiplex in some Member States prior to 2020 due to the adoption of the 790–862MHz sub-band) In addition, there are, of course, practical issues and risks involved with realising Scenario 3, in particular the need to coordinate the migration of households from the DTT platform to other platforms. Furthermore, the realisation of the benefits modelled in this scenario would require a political decision to be taken.

13.2.4 Scenario D: high DTT demand, low wireless broadband demand

The three figures below show the incremental costs and benefits in each spectrum supply scenario under Scenario D, where there is high DTT demand (DTT is significantly more valuable than in the low DTT demand case), and low wireless broadband demand. (See Figure 13.23, Figure 13.24 and Figure 13.25).

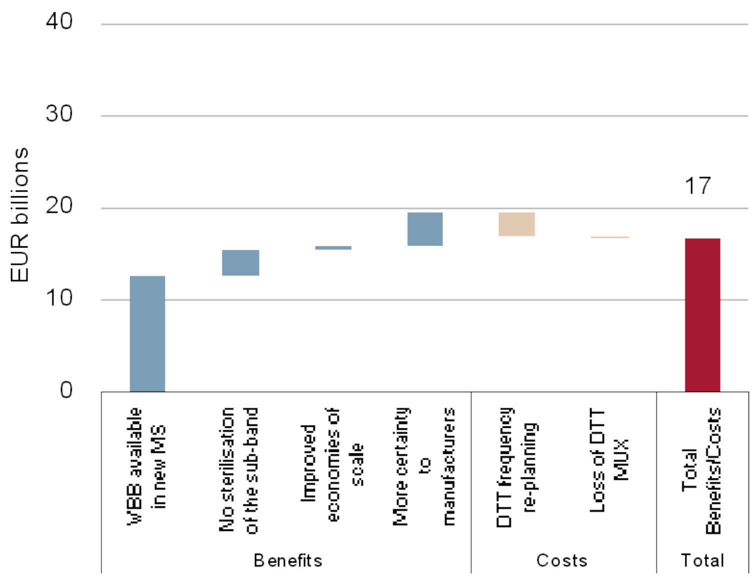

Figure 13.23: Incremental value of Scenario 1 under Scenario D [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

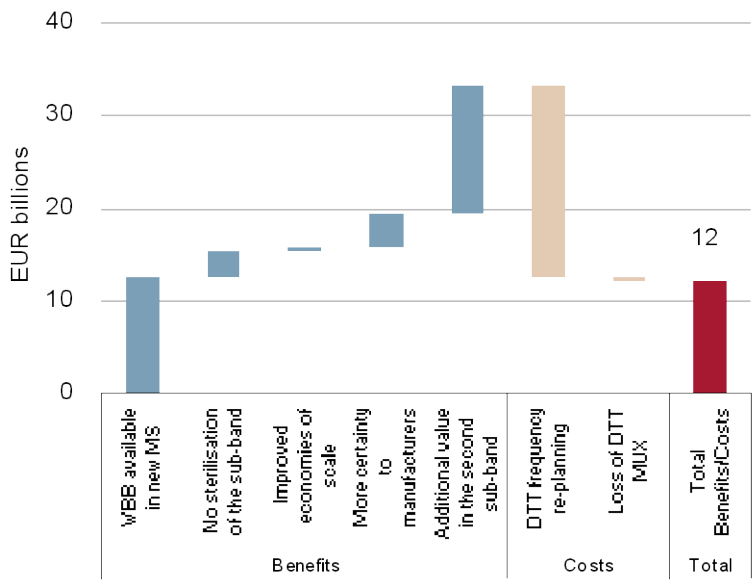

Figure 13.24: Incremental value of Scenario 2 under Scenario D [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

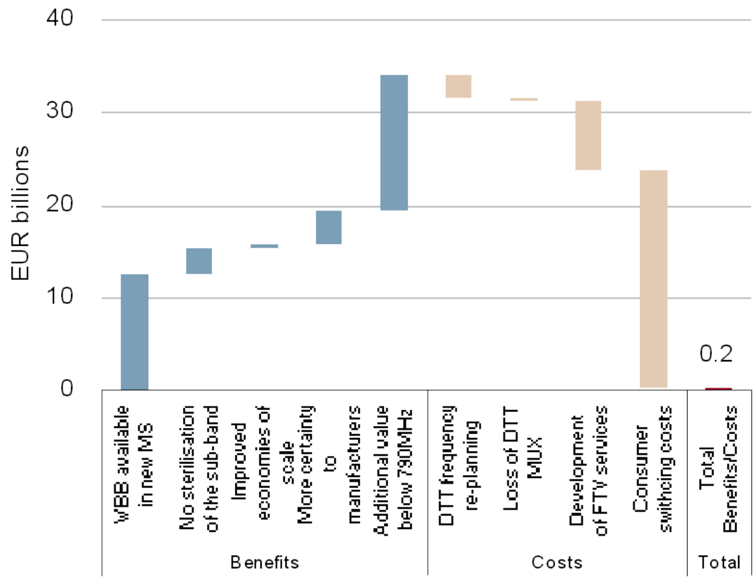

Figure 13.25: Incremental value of Scenario 3 under Scenario D [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

The results are very similar to those for spectrum demand Scenario A, as detailed in Section 13.2.1 above. This is because the loss of TV programming channels on the DTT platform is limited, as a result upgrades to the DTT platform, i.e. to MPEG-4. Therefore, the fact that DTT is significantly more valuable under Scenario D does not materially affect the results.

This enables us to conclude that even if the DTT service is much more highly valued in some Member States than existing studies suggest, there is sufficient scope to increase the efficiency of the DTT platform to preserve a sufficient number of TV programming channels while still identifying a sub-band that can be used for wireless broadband, or other lower-power uses.

13.2.5 Scenario E: high DTT demand, high wireless broadband demand

The three figures below show the incremental costs and benefits in each supply scenario under Scenario E, where there is high DTT demand (where DTT is significantly more valuable than in the low DTT value – we have assumed double the value per TV programming channel), and high wireless broadband demand (where the value of wireless broadband is at the higher end of the estimates from existing studies). (See Figure 13.26, Figure 13.27 and Figure 13.28).

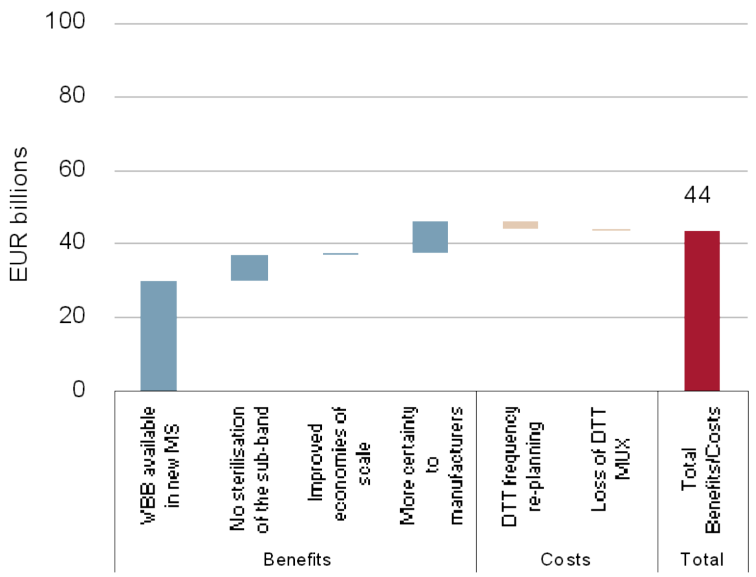

Figure 13.26: Incremental value of Scenario 1 under Scenario E [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

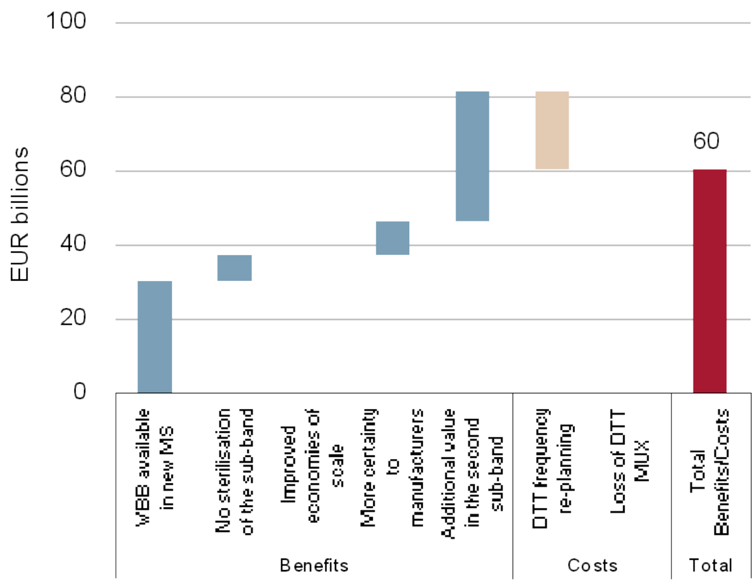

Figure 13.27: Incremental value of Scenario 2 under Scenario E [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

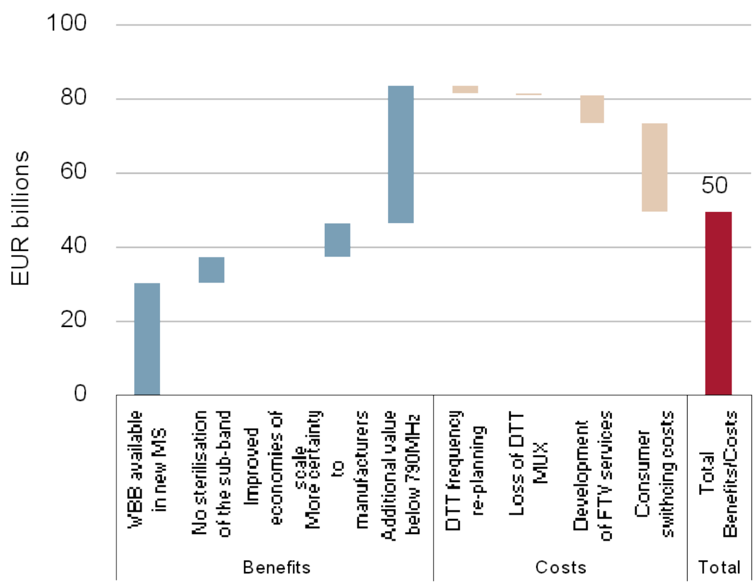

Figure 13.28: Incremental value of Scenario 3 under Scenario E [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

The conclusion is very similar to those drawn for spectrum demand scenario B in Sections 13.2.2. If wireless broadband is highly valuable, it appears beneficial to clear a second sub-band for its use, thereby constraining DTT to a smaller amount of spectrum. This need not lead to a large loss of consumer surplus, provided significant upgrades are made to broadcasting networks, moving to DVB-T2 and implementing SFN topologies.

13.2.6 Scenario F: high DTT demand, high wireless broadband demand and new uses

The three figures below show the incremental costs and benefits in each supply scenario under a Scenario F, where there is high DTT demand (DTT is significantly more valuable at the margin than in the low DTT demand case), and high wireless broadband demand (the value of wireless broadband is at the higher end of the estimates from existing studies), and there is a new, unknown use, which could deliver a significant value. (See Figure 13.29, Figure 13.30 and Figure 13.31).

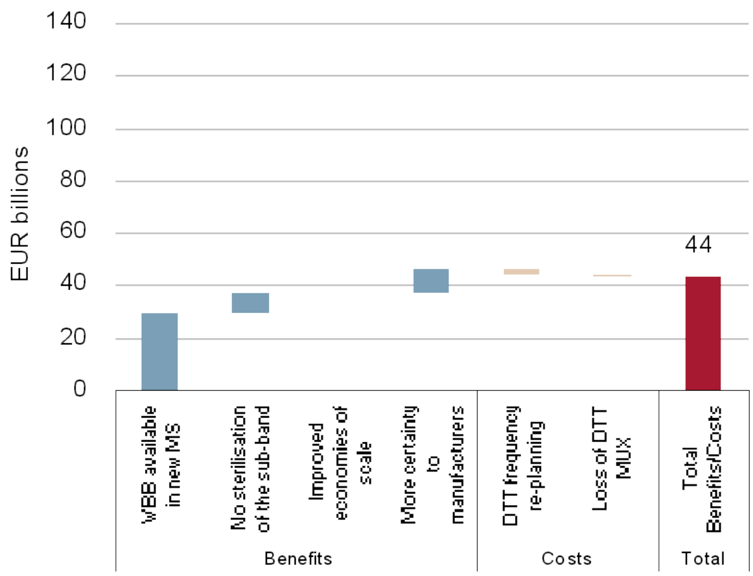

Figure 13.29: Incremental value of Scenario 1 under Scenario F [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

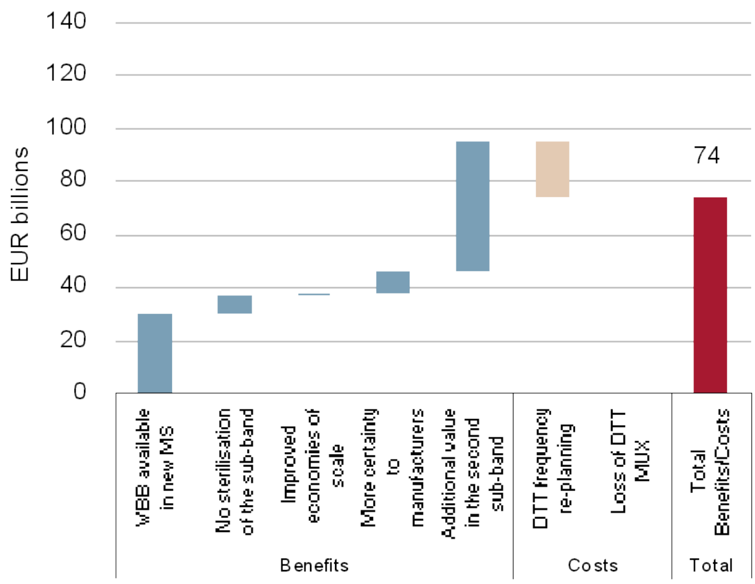

Figure 13.30: Incremental value of Scenario 2 under Scenario F [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

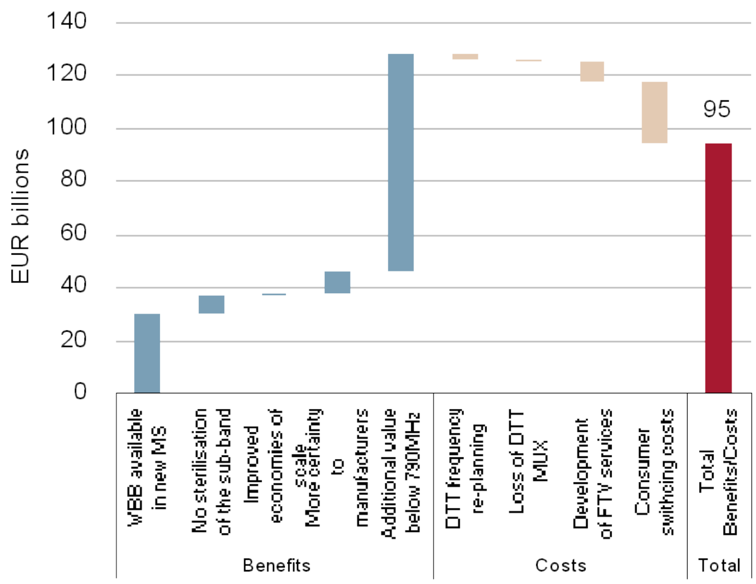

Figure 13.31: Incremental value of Scenario 3 under Scenario F [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

Our conclusion is very similar to that drawn in Section 13.2.3 for spectrum demand Scenario C. If a new high-value use of the spectrum emerges, it appears beneficial to clear additional spectrum for it, possibly clearing the whole band of high-power DTT. However, as mentioned in Section 13.2.3, our modelling assumes that there is no loss in consumer value from the switch to an alternative platform and that there is no loss from reduced TV platform competition. The difficulties and risks of this scenario also remain (including a requirement for a political decision to be made to facilitate band clearance).

13.3 Summary of results and observations

In this sub-section, we present a summary of results for our economic modelling and make some observations about the relative desirability of particular supply scenarios under different demand conditions. These observations are further developed in Section 15 in conjunction with our options for action at the European level discussed in Section 14. After presenting our summary results, we make a number of high-level observations. We then conduct sensitivity analysis on our results to understand how they would change if a different number of Member States adopt the 790–862MHz sub-band than assumed in our Reference Scenario. We highlight the limitations of our quantitative modelling, and offer some broader observations on each of the supply scenarios, which take into account issues not covered in our modelling such as TV platform competition effects, external value and political implications.

13.3.1 Summary of results

Figure 13.32 provides a summary of our modelling results. It presents the incremental private value generated by DTT, wireless broadband and (where applicable) a yet-to-be-determined new use for each combination of spectrum supply and demand scenario. Note that these results are relative to the Reference Scenario. For each demand scenario, we have highlighted in red in Figure 13.32 the private value associated with the optimal supply scenario.

	Incremental private value of supply scenarios relative to the Reference Scenario as of 2009		
Demand scenarios	***Scenario 1*** *(Sub-band for non-DTT use introduced at 790–862MHz)*	***Scenario 2*** *(Second sub-band in addition to the 790–862MHz sub-band)*	***Scenario 3*** *(DTT is cleared from the entire band)*
Scenario A *(DTT low, wireless broadband low)*	**EUR17 billion**	EUR13 billion	EUR1 billion
Scenario B *(DTT low, wireless broadband high)*	EUR44 billion	**EUR61 billion**	EUR51 billion
Scenario C *(DTT low, wireless broadband high with a new use)*	EUR44 billion	EUR75 billion	**EUR95 billion**
Scenario D *(DTT high, wireless broadband low)*	**EUR17 billion**	EUR12 billion	EUR0.2 billion
Scenario E *(DTT high, wireless broadband high)*	EUR44 billion	**EUR60 billion**	EUR50 billion
Scenario F *(DTT high, wireless broadband high with a new use)*	EUR44 billion	EUR74 billion	**EUR95 billion**

Figure 13.32: Summary of private value of demand and supply combinations [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

13.3.2 High-level observations

There are a number of high-level observations that can be drawn from these results.

- **Our Reference Scenario generates less private value than our alternative supply scenarios, irrespective of what happens to demand for key services.** The estimates of incremental private value range from EUR0.2 billion to EUR95 billion. This implies a potential case for EU-level action to influence supply away from the Reference Scenario.

- **The key drivers of private value are consumer demand forecasts for wireless broadband and other new services, rather than for DTT.** There are two reasons for this. Firstly, there is much less certainty over demand for wireless broadband and other uses than there is for DTT

(TV being a more established platform), so the potential variation between high and low-demand scenarios is smaller for DTT. Secondly, higher levels of demand for DTT can alternatively be realised by upgrading DTT technologies and deployment techniques, rather than by denying wireless broadband/other service access to spectrum.

- **Generally, lower demand for wireless broadband and other uses favours fewer changes to the existing spectrum allocation, while higher demand favours allocations in which more of the band is cleared.** The low-demand scenarios for wireless broadband (A and D) have the highest private value with adoption of a 790–862MHz sub-band only (Scenario 1); the high-value scenarios for wireless broadband (B and E) favour the adoption of a 790–862MHz sub-band (Scenario 2) and a second sub-band at 694–790MHz; and the high-value scenarios for both wireless broadband and another use (C and F) support the eventual clearance of the entire band (Scenario 3).

- **There is no unambiguously preferable supply scenario.** It is not possible to identify an optimal supply scenario from a private value perspective without greater certainty over future demand for wireless broadband and other uses. Nevertheless, the differences in their relative value according to the demand for wireless broadband, or other future uses, are sizeable. At the extremes, if demand for DTT and wireless broadband proves weak, clearance of the band for uses other than high-power DTT (Scenario 3) could result in a loss of EUR17 billion in private value, compared with only clearing the 790–862MHz sub-band (Scenario 1). Conversely, if demand is high for all types of service, restricting these uses to a 790–862MHz sub-band (Scenario 1) could mean an opportunity cost of EUR51 billion in private value relative to total clearance (Scenario 3).

Based on this analysis, we believe that current uncertainty about the demand for uses other than high-power DTT is the most important factor in influencing what spectrum allocation will benefit the EU the most. A definite and coordinated timetable for spectrum clearance would provide stronger incentives for DTT operators to develop and deploy more efficient broadcasting systems, and/or greater certainty about future spectrum availability for providers of wireless broadband and other services. However, the case for further clearance of the band beyond the 790–862MHz sub-band is very unclear. The risks of firm action to do so are that consumers and DTT operators may incur unnecessary costs in order to vacate spectrum for anticipated services and market demand that is not realised. These risks suggest flexibility is needed regarding coordinated European policy, in order to respond to future demand for non-DTT services and hence economically efficient demand for spectrum.

13.3.3 Sensitivity analysis

During the course of this study a number of Member States have announced plans to adopt the 790–862MHz sub-band (including Denmark, the Netherlands, Spain, and the UK). It is unclear how many Member States may make similar announcements in the absence of EU-level action to encourage the adoption of the sub-band. Therefore, in order to understand how our results would change to the split between Member States identifying a 790–862MHz sub-band in the Reference Scenario, we have conducted sensitivity analysis. We considered two sensitivities:

- Two additional Member States do *not* adopt the sub-band in the Reference Scenario. These two Member States are assumed to have a combine population of 56 million. This result in the Reference Scenario consisting of 14 Member States adopting the sub-band (with a total population of 338 million), whilst 13 Member States do not.
- Several more Member States adopt the sub-band in the Reference Scenario. We assume that six more Member States, with a combined population of 62 million adopt the sub-band. This result in the Reference Scenario consisting of 22 Member States adopting the sub-band (with a total population of 456 million), whilst just 5 Member States do not.

The summary of the first sensitivity is provided Figure 13.33 below.

	Incremental private value of supply scenarios relative to the Reference Scenario as of 2009		
Demand scenarios	***Scenario 1*** *(Sub-band for non-DTT use introduced at 790–862MHz)*	***Scenario 2*** *(Second sub-band in addition to the 790–862MHz sub-band)*	***Scenario 3*** *(DTT is cleared from the entire band)*
Scenario A *(DTT low, wireless broadband low)*	**EUR23 billion**	EUR19 billion	EUR7 billion
Scenario B *(DTT low, wireless broadband high)*	EUR60 billion	**EUR77 billion**	EUR66 billion
Scenario C *(DTT low, wireless broadband high with a new use)*	EUR60 billion	EUR91 billion	**EUR111 billion**
Scenario D *(DTT high, wireless broadband low)*	**EUR22 billion**	EUR18 billion	EUR6 billion
Scenario E *(DTT high, wireless broadband high)*	EUR59 billion	**EUR76 billion**	EUR65 billion
Scenario F *(DTT high, wireless broadband high with a new use)*	EUR59 billion	EUR89 billion	**EUR110 billion**

Figure 13.33: Summary of private value of demand and supply combinations if two more Member States do not adopt the sub-band in the Reference Scenario [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

The summary of the second sensitivity is provided Figure 13.34 below.

Demand scenarios	*Incremental private value of supply scenarios relative to the Reference Scenario as of 2009*		
	Scenario 1 *(Sub-band for non-DTT use introduced at 790–862MHz)*	***Scenario 2*** *(Second sub-band in addition to the 790–862MHz sub-band)*	***Scenario 3*** *(DTT is cleared from the entire band)*
Scenario A *(DTT low, wireless broadband low)*	**EUR8 billion**	EUR4 billion	(EUR8 billion)
Scenario B *(DTT low, wireless broadband high)*	EUR21 billion	**EUR38 billion**	EUR27 billion
Scenario C *(DTT low, wireless broadband high with a new use)*	EUR21 billion	EUR52 billion	**EUR72 billion**
Scenario D *(DTT high, wireless broadband low)*	**EUR8 billion**	EUR4 billion	(EUR9 billion)
Scenario E *(DTT high, wireless broadband high)*	EUR21 billion	**EUR38 billion**	EUR27 billion
Scenario F *(DTT high, wireless broadband high with a new use)*	EUR21 billion	EUR51 billion	**EUR72 billion**

Figure 13.34: Summary of private value of demand and supply combinations if six Member States do not adopt the sub-band in the Reference Scenario [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

As expected, if the number of Member States assumed to adopt the 790–862MHz sub-band in the Reference Scenario varies, our results also vary. However, there are two key observations:

- Although the private value generated is smaller if more Member States adopt the sub-band in our Reference Scenario, this effect is not linear. In other words, there are some benefits that we assume do not change with the number of Member States adopting the sub-band in our Reference Scenario. For example, we assume that this is the case for increased confidence for manufacturers. Firm action now at the EU level would have a similar affect, broadly regardless of the number of Member States that would have otherwise adopted the sub-band.
- Although in both sensitivities the magnitude of our results varies, the high-level observations discussed in Section 13.3.2 above remain valid.

13.3.4 Limitations of the modelling

A detailed review of the results must take into account some of the necessary limitations of the modelling. As emphasised in Section 12, the modelling captures only those aspects of the economic impact of different spectrum allocations for which quantitative evidence (from previous studies) exists, or for which reasonable assumptions can be made. These aspects are restricted to first-order impacts on private value, specifically:

- the incremental value of wireless broadband services to consumers, including the effect of increasing the population coverage of these services by removing interference from high-power DTT, as well as the effect of adopting additional sub-bands for wireless broadband
- the incremental costs of deploying wireless broadband networks and manufacturing consumer equipment to provide these services
- the incremental value to consumers of high-power DTT, and hence the loss in private value associated with the more restricted output of these services
- the incremental costs of upgrading the network infrastructure, standards and consumer equipment to compensate for the reduced amount of spectrum allocated to high-power DTT; in the most extreme case (Scenario 3), this would include replacing the DTT platform with an alternative platform
- a faster or slower roll out of services depending on the certainty to manufacturers and operators provided by different spectrum allocations (which accelerates or delays the associated economic benefits)
- the economies of scale and roaming benefits associated with different levels of EU-wide coordinated spectrum use.

However, as discussed in Section 8, a comprehensive definition of the economic impact of the digital dividend also involves:

- other possible effects on the total private value realised:
  - the impact of different spectrum allocations on network and platform competition and incentives for service innovation, and hence on the price[180] and quality of services to consumers. Note that our model includes these effects to an extent for wireless broadband, as some of the benchmarks that we have used from existing studies have taken these effects into account. For DTT, this is not the case. This is especially relevant to the case in which DTT ceases to exist as a rival TV platform to cable, satellite and potentially also mobile broadband TV and IPTV)

180 To the extent that the price of services determines only the division of total private value between consumers and producers, it does not matter to the calculation of total value generated, which is neutral as to whether the difference between the value and cost of services accrues to consumers as value for money (consumer surplus) or to business owners and shareholders as economic profit (producer surplus). However, where producers enjoy market power as a result of diminished competition, they will generally charge prices that improve profits while choking off a portion of consumer demand that would otherwise be satisfied, resulting in a net loss in total surplus (private value).

- broadcasters have argued that there is a incremental private value associated with the DTT platform. In other words the experience that consumers gain from the DTT platform cannot be replicated on other platforms. This view is supported by some existing studies (see Section 9.2). Again, this is especially relevant to the overall economic case in scenarios in which the DTT platform might cease to exist.

- existing studies have not included the cost of mitigating interference caused to cable networks (as introduced in Section 7.5). This issue has only been widely identified recently, and therefore, has not been included in historical studies. Therefore, this cost has been excluded from our private value results. We note that this cost may vary significantly between Member States depending on the nature and extent of cable roll outs.

- the external value of broadcasting and communications services to the economy as a whole, such as the increase in business efficiency and economic growth associated with an advanced digital economy
- the public value of broadcasting and communications services to society as a whole, such as the public service and regional policy dimensions of DTT, and the impact of wireless broadband in bridging the digital divide and improving social cohesion across rural and urban areas
- the political implications of realising these scenarios – in particular any decision to clear DTT from the entire band would be politically very sensitive, therefore, we expect that any decision to do so would need to be a political one.

While these sources of value are very difficult to quantify, they are integral to the total economic impact of the digital dividend and must be taken into account qualitatively when assessing the implications of spectrum different allocations.

Also, the optimal spectrum allocation between high-power DTT and other uses could vary from one Member State to the next. A balance is therefore needed between maximising benefits across the EU and enabling Member States to reflect on their individual situations. In particular, Member States that rely heavily on terrestrial TV services can be expected to place a higher value on spectrum being used for DTT than those in which alternative platforms such as cable and satellite are used extensively. Similarly, Member States with a high degree of regional diversity may have a higher demand for additional spectrum retained for DTT. Member States with large rural populations that cannot be served cost-efficiently by fixed broadband technologies, may benefit from emphasising wireless broadband in their spectrum allocations. Finally, the cost of clearing part of the band may vary significantly between Member States.

Existing studies do not provide sufficient evidence to support a bottom-up, country-by-country analysis of the relative economic benefits of different spectrum allocations. For this reason the results of the top-down modelling exercise must be assessed in the context of individual Member States’ circumstances.

13.3.5 Broader observations for each supply scenario

Due to the limitations associated with the quantitative modelling, it is appropriate to review our observations for each supply scenario in light of the other factors that may impact overall economic value. We also consider how certain observations might be modified in response to specific circumstances in particular Member States.

Scenario 1: high-power DTT is used in 470–790MHz, and a 790–862MHz sub-band is identified for a common use

A striking result from the modelling of Scenario 1 is that EU-wide clearance of a 790–862MHz sub-band could improve the economic benefit generated by the digital dividend even *before* taking account of the European dimension of benefits. For each of the demand scenarios, the incremental benefit from wireless broadband services being made available in these Member States greatly exceeds the total economic cost of clearing the first sub-band, in terms of a reduction in DTT multiplexes and/or the cost of DTT network upgrades. One interpretation of this result is that Member States that are not planning to adopt the 790–862MHz sub-band may not be currently planning their digital dividend spectrum allocations optimally, irrespective of the European dimension.

Of course, this does not consider individual national circumstances. In principle, there may be localised affects not taken into account in the modelling, which could change the result for specific countries. Notably, a number of Member States face legal and technical difficulties in clearing the upper part of the 470–862MHz band because of allocation decisions already made at GE-06. As discussed in Section 7.5, use of wireless broadband in the sub-band may cause interference with cable networks, the extent of this issue and the cost of mitigating it may vary between Member States. Also, several of those Member States are near the EU's eastern border, which is subject to interference from high-power uses of the 790–862MHz sub-band from neighbouring, non-EU countries. As discussed in Section 6.5.1, Russia's analogue switch-off is likely to occur later than the EU's target date of 2012, and its plans for the 790–862MHz sub-band are currently unclear. It is also unlikely that Russia's plans will be resolved before 2015. Consequently, even if these Member States were to commit to clearing the sub-band for wireless broadband or other uses, it is possible that they would not be able to realise the full benefits in the timescales assumed in our modelling i.e. from 2013 onwards. Thus, the model results should be taken as an indication of the strong case for coordinating an EU-wide plan for clearance of the 790–862MHz sub-band with non-EU neighbouring countries, as well as assisting Member States to overcome technical and legal obstacles to this clearance. Some Member States may also have public policy grounds for allocating the entire band to DTT not captured in the top-down modelling.

Nevertheless, the scale of private value benefits from wireless broadband (even in the low-demand scenarios) is such that there would need to be compelling grounds for individual Member States *not* making any of the 470–862MHz band available for other services. Regarding incremental external value, as discussed in Section 9.1, we found no strong evidence to suggest that this would alter the trade-off between wireless broadband and DTT for the 790–862MHz sub-band. In fact, we concluded that the marginal external value associated with removing DTT from the sub-band was likely to be small, provided DTT still had access to a critical mass of spectrum outside the sub-band.

In conclusion, our modelling strongly suggests that firm action to clear the 790–862MHz sub-band following the digital switchover (DSO) could deliver significant overall benefits to the EU. Even assuming low demand for wireless broadband services, the additional private value created appears to outweigh the costs, in terms of reduced DTT output or compensating measures to accommodate planned DTT services below 790MHz.

Scenario 2: high-power DTT is used in a core band, and two sub-bands are identified

Our modelling suggests that the case for the adoption of a second sub-band (Scenario 2) is highly dependent on there being sufficient demand for wireless broadband or other services to justify the costs of replanning DTT into a smaller part of the band. This is because the additional private value created by wireless broadband or other uses under Scenario 2 is limited to the incremental value over and above that generated by wireless broadband using the 790–862MHz sub-band. Further, clearance of the second sub-band would require a significant reduction in the spectrum available to DTT, meaning that there must be a substantial reduction in DTT output and/or significant upgrades to DTT networks and consumer equipment.

A notable observation from our modelling is that the adoption of a second sub-band in the medium term (to 2018, approximately) may be preferable over a middle range of demand outcomes.

- Under low-demand scenarios for wireless broadband and other uses, we find that it is optimal to clear only the 790–862MHz sub-band (Scenario 1); clearing a second sub-band (Scenario 2) would forfeit EUR4 billion.
- Under high-demand scenarios for wireless broadband but excluding demand for other uses, Scenario 2 is optimal. It offers significant private value gains over Scenario 1 (EUR17 billion) and Scenario 3 (EUR11 billion).
- In the cases of high-demand for wireless broadband and other uses, Scenario 2 appears significantly less valuable than Scenario 3. The adoption of a second sub-band does generate incremental values of circa EUR30 billion relative to having just the first sub-band, but clearing the entire band could generate an additional EUR21 billion.

We note, however, that our modelling approach may tend to reduce the range of outcomes under which adoption of a second sub-band appears optimal. We are more confident about our assessment of the relative private values of Scenarios 1 and 2 than we are of Scenario 3. In particular, there is a risk – discussed below – that we may be underestimating the loss of value associated with clearing DTT entirely from the band (Scenario 3) as we do not include any estimates for platform competition affects or the loss in private value by substituting the DTT platform with other platforms. It should also be noted that, except in the very long term, adoption of a second sub-band may be significantly more palatable from a political perspective than clearance, given the significant ramifications for consumers in Member States where terrestrial television is popular (e.g. the logistics and cost of switch consumers to other platforms).

Scenario 3: high-power DTT is not used in the 470–862MHz band

Scenario 3 is the most radical departure from the Reference Scenario as it involves clearing high-power use from the entire 470–862MHz band by 2020. In many respects this should be considered as a theoretical scenario, since any decision of this nature would require a political decision to be taken by Member States. If this scenario were to be implemented, we assume that free-to-view services currently carried by DTT, including regional and local content, would continue to be offered using other platforms instead.

The incremental private value associated with Scenario 3 is smaller than Scenario 2 for low and high wireless broadband demand scenarios. However, Scenario 3 has the advantage of making large amounts of spectrum available for potential future uses. Consequently, in the most extreme demand scenarios (C and F), Scenario 3 emerges as being more beneficial in terms of its contribution to private value, because of the greater availability of spectrum for these new and valuable services.

The quantitative modelling may, however, tend to overstate the benefits of clearing DTT from the band, as it may underestimate the loss of value associated with eliminating high-power DTT. Firstly, loss of DTT could have negative effects on consumers' choice, by reducing platform competition to just satellite and/or cable (unless IPTV and broadcast mobile TV emerge as significant rival platforms). DTT is already viewed as a significant competitor to these platforms in many Member States, encouraging innovation and competition in the services offered to consumers. The impact of the loss of DTT, in terms of reduced incentives to provide innovative, high-value and competitively priced services, would depend on the ability of satellite/cable-based free-to-view services to compete with pay-TV services.

Secondly, there is evidence from existing studies (see Section 9.2) that consumers' valuations of TV services are affected by the platform. For example, survey work undertaken for Ofcom in the UK suggests that consumers in Member States where television has traditionally been delivered by terrestrial means strongly favour DTT, and may resist adopting other platforms. Given that other platforms can typically replicate all content available over DTT, and carry additional content, these findings may initially appear counter-intuitive. One possible explanation is that DTT platforms in many Member States are disproportionately associated with popular public service TV programming channels, and that consumers fear that the quality of these services may deteriorate if only available on alternative platforms. In addition, many consumers apparently dislike satellite dishes, which could be a source of dissatisfaction with satellite access to free-to-view services (which may be the only platform alternative to DTT in rural areas).

Finally, as discussed above, clearance of DTT would be a very sensitive political decision in many Member States, given the significant upheaval for broadcasters and consumers. Certainly, given that most Member States are currently undergoing the DSO process, which involves the promotion of the DTT platform, it would be many years before it is realistically feasible to launch new campaigns aimed at turning off DTT and migrating customers to other platforms.

These factors, while hard to quantify and even to identify precisely, should still form part of the overall evaluation of any proposal to clear high-power DTT from the 470–862MHz band. Whether they are long-term arguments against such a proposal in part depends on whether these preferences are transient or more permanent.

Overall, the case for eventual clearance of the whole 470–862MHz band is highly dependent on the future demand for wireless broadband and/or other new uses. Therefore, an early commitment to this course of action would be unwarranted. Nevertheless, despite Scenario 3 being more radical than the other supply scenarios, there is a clear case for keeping this option open, based on strict economic analysis, in case the value of digital dividend spectrum for wireless broadband and/or other uses proves to be high.

14 Options for EU-level action

In Section 13, we identified potential economic outcomes under different spectrum supply and demand scenarios for the use of the 470–862MHz band. A key observation was that under all likely demand scenarios, the optimal spectrum supply scenario differed from our Reference Scenario. This means that if Europe pursues its current course, with some but not all Member States implementing a 790–862MHz sub-band, the economic outcome for Europe as a whole is likely to be sub-optimal.

This suggests that there is a potential benefit from coordinating action at the European level in order to influence the availability of spectrum in the 470–862MHz band. Therefore, the next step is to identify potential options for this EU-level action that could influence the supply and demand for spectrum over the short (circa 2012), medium (circa 2018) and long term (circa 2023).

Broadly, there are two types of option:

- **high-level actions**, which influence the availability of spectrum, either for individual uses or for broad categories of use
- **sector-specific actions**, which may influence demand for spectrum via technological change, the introduction of more efficient deployment strategies or changes to end-user demand.

The high-level actions will determine the broad balance of spectrum available to DTT, wireless broadband and other uses. Service-specific measures may tend to strengthen the economic basis for a particular approach to spectrum management, e.g. by encouraging one type of use spectrum more efficiently, thus potentially freeing up spectrum for other uses. In Section 14.1, we first identify the options for high-level action, then in Section 14.2 identify sector-specific actions that could either re-enforce the benefits of a particular high-level action or are justified in their own right, regardless of the high-level approach.

The timeframe for action is very important to our analysis. The ability of the Commission to influence spectrum availability in the short-term may be quite limited, owing to the need to preserve economic value associated with incumbent uses of the 470–862MHz band, and to take account of decisions already made by Member States. However, where there is scope for action with immediate consequences, it should be possible to form reasonably confident assessments of their economic impact, as we know much more about the relative value of potential uses over the short to medium term than we do over the long term. By contrast, there may be much more scope to initiate actions that will influence spectrum availability over the medium to long term. However, caution is needed when considering any commitment to a particular technology or service, given the scope for significant changes in demand from existing services and the potential emergence of new uses.

Consequently, the timing of potential actions and the need to balance certainty with the flexibility to adapt to developments as they emerge, are important considerations in the Commission's strategy for the digital dividend.

14.1 High-level options

The current plan is for high-power DTT to be the primary use for the 470–862MHz across Europe. At the European level, there is no specific requirement for Member States to make any spectrum available for other uses[181], or for them to coordinate the availability of common sub-bands for other uses. In practice, there are already bilateral and multilateral initiatives amongst SMAs to coordinate some non-DTT use in the band, in part encouraged by the Commission. However, these initiatives are mainly narrowly focused on the short-term goal of making the 790–862MHz sub-band available for wireless broadband, and their ability to realise as consistent an outcome across Member States is uncertain. In summary, there is no EU-level strategy for coordinating the availability of spectrum other than for high-power DTT, and little in the way of long-term planning for how the use of the band may evolve over time.

Thus, at the highest level, there is scope for European action to coordinate the availability of spectrum for non-high-power DTT uses across the EU, and to promote long-term flexibility in how different parts of the band are used.

Accordingly, we have identified four high-level options, these are:

- adopting the 790–862MHz sub-band, suitable for wireless broadband deployment across the EU
- adopting a second sub-band, suitable for uses other than high-power DTT
- promoting the long-term availability of the entire 470–862MHz band for uses other than high-power DTT (noting that this is an extreme option and a political decision would be required by Member States prior to any implementation)
- encouraging use of interleaved spectrum within the 470–862MHz band.

Why these four options? The first three correspond roughly to our supply scenarios in Sections 12 and 13. They involve escalating levels of action that would potentially redistribute spectrum away from high-power DTT and towards other uses. Depending on the timeframes in which implementation is considered, they may be either alternative options or consecutive steps. In each case, there is an emphasis on coordinating the availability of spectrum for other uses. The fourth option concerns making the best use of vacant spectrum that may be available due to the deployment of DTT (especially if MFN topologies are deployed) and possibly other primary uses in the band.

181 The electronic communications regulatory framework does, however, require Member States to make allocation and assignment decisions relating to newly available spectrum on a non-discriminatory, proportionate and transparent basis. Exceptions are allowed to fulfil general interest objectives or to ensure efficient use of the spectrum; such exceptions are required to be proportionate to the underlying objective. If Member States were to dedicate the whole 470–862MHz band to DTT, they could be required to justify this decision.

For each of these four options, we identify below a range of possible actions that the Commission could take to facilitate their realisation. We also discuss the potential advantages and disadvantages of these actions as a tool for realising beneficial spectrum supply outcomes. This discussion feeds into our evaluation of the economic impact of the proposed actions in Section 15. Where appropriate, we differentiate between those actions that may be adopted in the short, medium or long term, as this may have a significant impact on the realisation of economic value.

14.1.1 Actions supporting the adoption of a 790–862MHz sub-band

As described in Section 6.3, there is a growing momentum across Europe behind proposals to clear and award a common band across Europe at 790–862MHz, as identified at WRC-07. It is widely envisaged that this band would be used by mobile network operators to provide wireless broadband, most likely using UMTS[182] or LTE technology. A specific band plan with fixed duplex spacing (791–821MHz paired with 832–862MHz) has already been identified that would be suitable for such deployments. In anticipation or in response to this initiative, a number of SMAs have already initiated action to clear the sub-band. In some cases, this has involved bilateral and multilateral negotiations to coordinate the redistribution of DTT allocations to spectrum below 790MHz. It now seems likely that some Member States will hold award processes in time for the deployment of services from 2012.

The political and economic momentum behind adopting a sub-band at 790–862MHz is such that no alternative configuration of frequencies appears desirable. As this study has shown, there is a potentially large economic value associated with the adoption of a sub-band through economies of scale and certainty for manufacturers, but the realisation of this value depends on a critical mass of Member States committing to the sub-band. If, as seems likely, the preferred wireless technology is UMTS or LTE, then these benefits can only be realised if Member States adopt the same paired band plan. The implication of this is that a larger sub-band is not feasible in the short term because this would require a different band plan, which in turn would require Member States to revisit their plans for redistributing DTT assignments. A smaller sub-band might be feasible but is probably not desirable, given the large number of Member States already working towards the current plan, and the potentially high value associated with using spectrum for wireless broadband. More generally, any attempt to revise the size and frequency location of the band could result in lengthy delays to award processes and push back deployment beyond 2012.

In this context, action to support the adoption of the 790–862MHz sub-band seems a firm proposition. The options we consider for further EU-level action instead concern the more specific questions of whether the additional step should be taken to compel all Member States to clear and award this spectrum, how far to constrain its use to particular services and/or technologies, and what timeframes should be applied to these options.

182 Including variants of UMTS such as HSPA and HSPA+.

For this option the potential actions are:

1. ***Maintaining the current policy of strongly encouraging Member States to clear and award the 790–862MHz sub-band, but without more formal measures***

   Currently, it seems likely that many Member States will adopt the 790–862MHz sub-band. However, some remain undecided over whether they will adopt the sub-band, and one Member State (Malta) has said it intends to use these frequencies for high-power DTT. Thus, without further action, it is possible that adoption of the sub-band will be only partial. This implies some loss of economies of scale and roaming benefits, increased uncertainty to manufacturers, and restrictions on wireless deployment in some border areas in order to protect DTT reception in neighbouring Member States from interference.

   Actions that could be considered under this option include either requesting or obliging that Member States share their plans publically for the adoption of the sub-band. This would provide increased certainty to industry, particularly for equipment manufacturers, and the availability of plans may lead to Member States reconsidering their own plans. Non-mandatory guidelines could also be provided for the adoption of the sub-band (e.g. a guideline timeframe of 2012 in all Member States, or 2015 for those that border non-EU countries that are not committed to the sub-band). While such guidelines would not be obligatory, they could gain momentum leading to a more widespread adoption of the sub-band than would otherwise have been the case. We note that the proposed timescale of 2012 for ASO across the EU (as detailed in COM(2005)04) despite not being a obligatory requirement, acquired momentum, resulting in the vast majority of Member States setting an ASO date to meet this target date.

   Continued Commission support for the sub-band may yet encourage more Member States to adopt the sub-band, especially those that are undecided, but this cannot be guaranteed. Therefore, one must suppose that under this approach, there is a high likelihood that some Member States will continue to deploy high-power DTT in the 790–862MHz sub-band, as is described in our Reference Scenario. This approach may, however, be welcomed by some Member States, as it leaves intact their current autonomy to decide between high-power DTT and other services according to their own assessment of the national interest.

2. ***Reversing the priority regarding interference coordination away from high-power DTT and in favour of wireless broadband***

   One way of encouraging the adoption of the sub-band for wireless broadband would be to remove the priority given to protecting DTT assignments in the 790–862MHz sub-band and instead prioritise the protection of medium-power uses such as wireless broadband. Under this action, it would still be possible for some Member States to chose *not* to adopt the sub-band and instead continue to prioritise high-power DTT across the whole 470–862MHz band. However, because Member States prioritising high-power DTT above 790MHz would now have to avoid interference to wireless broadband systems in neighbouring Member States, they would be restricted in their use of high-power DTT in border areas. This would increase the benefits for Member States deploying wireless broadband and correspondingly decrease benefits for Member States deploying high-power DTT. For some Member States, this may undermine the case for using high-power DTT in the sub-band, thus encouraging them to adopt the majority approach.

3. ***Requiring all Member States to clear the 790–862MHz sub-band and award it on a service- and technology-neutral basis***

A further step, which could potentially be introduced together with the second action above, would be to oblige all Member States to clear high-power DTT (and any secondary uses) from the 790–862MHz sub-band, so that it could be made available to new uses through a spectrum award. For this action, we assume that no specific use would be mandated and the award would be consistent with the Commission's WAPECS concept.[183] Nevertheless, there would be an expectation, which could be made explicit, that Member States would ensure that the highest value uses of the spectrum were able to bid for the spectrum without undue uncertainty. Accordingly, some Member States may chose to adopt band plans that favour UMTS/LTE, while other Member States may adopt more flexible band plans and allocation mechanisms (either auctions or beauty contests) that allow the market or government to chose between competing uses.

This approach is likely to greatly increase the probability of Europe-wide adoption of wireless broadband, especially if the 790–862MHz sub-band was awarded using auctions in all Member States. Based on an assessment of current market conditions, it seems unlikely that any use (including high-power DTT) could compete with the business case for UMTS/LTE based on a common European band plan. However, this approach does still provide scope for Member States to adopt different services and technologies if local conditions vary significantly, and is also potentially resilient to any sudden change in market sentiment against UMTS/LTE and in favour of other wireless broadband technologies or other services. However, the price of this flexibility is a degree of uncertainty for potential users in one Member State over actual deployments in neighbouring Member States. In particular, depending on the specific spectrum packaging and award mechanisms that individual SMAs adopt, applicants for the spectrum in one Member State might face uncertainty over the interference environment from a neighbouring Member State that has not yet held its award.

This approach is very similar to that taken by the European Commission for the 2.6GHz band (see the 2.6GHz Decision 2008/477/EC). According to this Decision, Member States are required to make the 2.6GHz band available on a service- and technology-neutral basis

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183 Wireless Access Policy for Electronic Communication Services (WAPECS) is the name given to initiatives to apply service and technology-neutral licensing conditions to different spectrum bands, based on the concept of Block Edge Masks (BEM) rather than technology specific usage conditions.

subject to adopting emissions restrictions that favour the most likely highest value use: UMTS/LTE.

4. ***Requiring all Member States to clear the 790–862MHz sub-band and awarding authorisations for wireless broadband with common technology restrictions and common band plan***

   The Commission could go one step further than action 3 above, and require all Member States to make the 790–862MHz sub-band available for wireless broadband using a common band plan and common technology (presumably either UMTS or LTE). This approach should guarantee the universal adoption of wireless broadband in the band (barring an unexpected slump in demand from potential users), thus maximising the benefits from economies of scale, roaming and certainty to manufacturers, and largely eliminating interference concerns at borders.

   Notwithstanding these potential benefits, this approach would be a represent a significant departure from the Commission’s stated preference for technology and service neutrality (its WAPECs concept). The downside of mandating a specific use is that it commits the EU to a particular technology for the 790–862MHz sub-band, potentially for the duration of the licences. If sentiment towards the chosen technology changes, this may result in inefficient use or even sterilisation of valuable spectrum. Even if spectrum trading and change of use are introduced later, rigidities in the band plan might make it difficult for alternative uses of the spectrum to access the sub-band.

The above actions are not necessarily mutually exclusive, and it may be appropriate for the nature of European action to change over time. For example, firm action (actions 2–4 above) may be harder to justify before 2015, as some Member States may face significant domestic policy constraints on their ability to complete digital switch-off (DSO) before then. Also some Member States may accrue little benefit from making the sub-band available before neighbouring non-EU countries complete their DSO, due to interference from high-power DTT in these countries. Therefore, one option would be to encourage the take up of the sub-band prior to 2015, but to follow this with obligatory action (which could take the form of actions 2, 3 or 4 above) that comes into force from around 2015.

14.1.2 Actions for the adoption of a second sub-band

In addition to the adoption of the 790–862MHz sub-band, there may (in the future) be a potential case for clearing and awarding further spectrum in the band; we refer to this as the ‘second sub-band’. The second sub-band could be used for more wireless broadband, using similar or different technologies to the 790–862MHz sub-band or for one or more completely different uses, such as PPDR or an innovation reserve. Whilst the economic case for such a second sub-band is currently uncertain, if the certainty were to increase and a clear economic benefit were to become apparent, the political acceptability of/desire to create a second sub-band in Member States may significantly increase.

The size and frequency location of any second sub-band are important variables that would need to be subject to detailed consultation and review. One leading option is to adopt a sub-band immediately between the remaining DTT allocations and the 790–862MHz sub-band. This approach would minimise the number of potential frequency borders between high-power DTT and other uses. For our economic analysis, we have considered a sub-band of 694–790MHz. Stretching the sub-band down to 694MHz would make available a substantial amount of spectrum, making possible a wide range of new uses, and would also allow for potential coordination with sub-bands on other parts of the world, such as the lower 700MHz sub-band in the USA, which starts at 698MHz.

Adopting a second, common sub-band across the EU would have a significant impact on the deployment of high-power DTT. In this case, high-power DTT services would have to be squeezed into the frequency range 470–694MHz. This equates to a reduction in spectrum capacity of over 40% compared to today (or about 30% when compared to making just the 790–862MHz sub-band available for non-DTT), but the proportion of multiplexes affected would likely to be much greater, as most are currently coordinated on an MFN basis with assignments across the 470–862MHz band. Thus in order to avoid a significant reduction in DTT capacity, some or all of the following may be required:

- greater use of SFNs instead of MFNs
- the introduction of more spectrally efficient transmission and compression technologies (e.g. DVB-T2 and MPEG-4 instead of DVB-T and MPEG-2)
- a major replanning exercise amongst Member States.

As discussed in Section 13, some of these changes may be expensive to implement, for example greater use of SFNs may require many new transmission sites and realigning aerials.

A key issue is the timing of the clearance of the second sub-band. Given the cost and logistical challenges of adopting SFN topologies for DTT in many Member States, this is unlikely to happen before the medium term. Currently, a number of Member States are going through a protracted period of analogue/DTT simulcasting until ASO can viably occur, and future digital technology upgrades may also require the simulcasting of TV programming channels. Thus, vacating the second sub-band will not be desirable in the short term. Meanwhile, our economic modelling suggests that the economic case for making spectrum available to new uses other than high-power DTT beyond 790–862MHz sub-band is dependent on there being high demand in the future for wireless broadband and/or other uses. These considerations suggest that it may be detrimental to adopt a second sub-band in the short term, and also that some future flexibility should be maintained while these technological and market uncertainties are resolved.

We have identified three potential actions that could facilitate the adoption of a second sub-band:

1. ***Studying the possibilities for adoption of a second sub-band, with the possibility of more assertive actions (see below) at a later stage***

   The least interventionist action would be to identify the possibility of a second sub-band and initiate investigations on the frequency location of this band and possible uses. At a European level, such investigations could, for example, be led by the RSPG and CEPT, and may consider issues such as potential band plans for the second sub-band. There would be no certainty that this would lead to any firm action to clear and re-award specific frequencies, such as the 694–790MHz range. Nonetheless, the possibility of action could be expected to stimulate initiatives by potential new users and equipment manufacturers to develop business cases relating to the second sub-band.

   The effectiveness of this approach would depend on the level of cooperation from Member States. Ideally, Member States may launch their own parallel investigations into the scope for reorganising DTT to free up spectrum for a second sub-band; however, this may be difficult to achieve unless and until there is direction from a European level on the specific frequencies that could be cleared. This in turn may mean that any subsequent recommendation to go ahead with adopting a second sub-band would be subject to long delays before implementation. More generally, uncertainty over whether clearance will happen may mean that there is little incentive for DTT users to migrate to more efficient technologies and network topologies, as DTT providers may be concerned that such action will only serve to bring forward them losing access to spectrum. On the other hand, if demand for other services proves to be weak, it may not be economically efficient to adopt a second sub-band.

   One drawback of this approach is that the long timeframe may encourage some Member States to press ahead with their own plans to release spectrum below 790MHz on an uncoordinated basis. At the Member States workshops held in April and June 2009, there appeared to be relatively little appetite for adopting a second sub-band, but this may change with time, and at least one country (the UK) has provisionally identified a second sub-band, in Channels 31–38 (550–614MHz), for release to new uses. This may make any subsequent attempt to coordinate the adoption of a common sub-band difficult.

2. ***Directing Member States to plan for possible clearance and award of a second sub-band under a provisional timetable***

   A stronger action would be to direct Member States to plan for the possible clearance and award of a second sub-band (or a limited number of alternative sub-bands) according to a fixed timetable. The advantage of this approach is that the EU would be ready to move very quickly in response to changes in demand or technology conditions. However, the actual decision on whether to implement any particular replanning exercise is likely to be politically sensitive and does not need to be taken now on the basis of incomplete information, but rather can be deferred until more information is available.

In order to follow this approach, preparatory work on identifying the frequencies to be cleared would have to be accelerated. However, it may not be necessary for Europe to make an early decision on the specific frequencies to be cleared. For example, it might be sufficient for the Commission to identify the spectrum below 790MHz as suitable for a second sub-band and ask Member States to explore options for a limited number of possible band sizes.

The ability to respond quickly to an upward demand shock for new uses is a potentially significant advantage over action 1 above. This is because the earlier adoption of valuable new services may offer substantial economic benefits. Moreover, the replanning exercise would provide a strong signal to the DTT industry that they need to plan for the possibility of a reduction in their spectrum allocation, which may incentivise a migration to more efficient technologies and network topologies. This is potentially beneficial whether or not high-power DTT is ultimately cleared from the second sub-band, as reforms would also increase DTT capacity which in itself would generate economic benefit. This approach may also deter Member States from identifying their own sub-bands, as there would be a strong expectation of EU action if conditions supported this.

This flexibility suggests the potential economic downsides of this approach appear limited. There is, however, a potentially significant planning burden on SMAs. In particular, requiring Member States to replan DTT networks for multiple frequency release scenarios may be onerous.

3. ***Requiring Member States to adopt a second sub-band within a particular timeframe***

The strongest possible action would be to require Member States to adopt a second sub-band. This action could take any of the three forms outlined in actions 2–4 for the 790–862MHz sub-band (see Section 14.1.1 above):

- reversing the priority in interference coordination between Member States in favour of wireless broadband and away from high-power DTT
- requiring all Member States to clear and award the second sub-band and making it available on a service- and technology-neutral basis
- requiring all Member States to clear the second sub-band and licensing it for wireless broadband with common technology restrictions and band plan.

In general, a more certain timetable for a second sub-band would provide both stronger incentives for DTT operators to develop and deploy more efficient broadcasting systems, and greater certainty about future spectrum availability for providers of wireless broadband and other services, giving a firmer basis to plan future offerings. However, the risk of setting a more definite and aggressive timetable is that DTT operators may incur unnecessary costs in order to vacate spectrum for which anticipated services and market demand do not then materialise, or do so more slowly than expected.

At present the case for a second sub-band is uncertain. Therefore, this action does not seem sensible in the short term. In addition, such an option is unlikely to have the necessary political support given current uncertainties. A second-sub-band, however, may become viable over the coming years as new evidence emerges about demand for new uses. Therefore, we see this action as a medium-term option, possibly as a follow-on to actions 1 or 2 above.

14.1.3 Complete clearance of the 470–862MHz band

As we have seen, adopting a second sub-band would significantly reduce the spectrum available for high-power DTT, and this would require major changes to the DTT technologies and/or topologies used in order not to unduly reduce DTT services. Without major technological changes, further reductions in spectrum for high-power DTT may not be possible without undermining the viability of the DTT platform in many Member States. Therefore, the logical step beyond adopting a second sub-band would be to clear high-power DTT from the whole band.

We note that this is a radical and extreme option and would require a political decision to be made by Member States. Further, we do not regard this as a plausible short-term action. It would mean writing off substantial investments across Member States in developing the DTT platform and result in the removal of services widely used in many Member States. However, it is worth considering this as a possible longer-term action, since it is possible that changes in the relative value generated by DTT and other potential uses over these timeframes could significantly increase the economic benefits of such an approach and change political sensitivities on this matter. In practice, by the time a decision to clear the band was made, the 790–862MHz sub-band would almost certainly be in place in most or all Member States.

More generally, we can identify four possible paths for the clearance of high-power DTT from the entire band:

- *In the medium term, as a second step after adoption of the 790–862MHz sub-band and instead of a second sub-band.* For this to be an economically beneficial possibility, there would have to be either a very substantial rise in demand for new uses or a significant reduction in demand for DTT services. Otherwise, a medium-term timeframe for clearance would almost certainly be too soon to justify writing off the widespread corporate and consumer investment in DTT networks and receivers.

- *In the long term, again as a second step after adoption of the 790–862MHz sub-band and instead of a second sub-band.* This is a more plausible potential option, as it implies a scenario and timescale in which the existing DTT platform may anyway be approaching the end of its natural life, such that associated equipment has substantially depreciated in value.

- *In the long term, as a third-step after adoption of both the 790–862MHz and second sub-bands.* We doubt this is attractive under the timescales suggested. A move to adopt a second sub-band rather than band clearance in the medium term implies that the costs of replanning DTT can be justified. If this is the case, then it is relatively unlikely that it would be appropriate to write-off these investments to clear high-power DTT out of the whole band just four to six years later. Rather, we would expect the gap between adoption of a second sub-band and any complete clearance of high-power DTT to be at least ten years.

- *On expiry of existing DTT licences (and licences in the 790–862MHz sub-band if applicable).* This again is plausible as a possible option. DTT licences will typically expire from the mid-2020s onwards, by which time spectrum demand and technology conditions may well have changed significantly. With 790–862MHz licences also coming to an end at a similar time, this timeframe may allow for a complete replanning of the 470–862MHz band.

In this context, the potential EU-level actions look similar to those for the adoption of the second sub-band, but with more fundamental implications for the use of the whole band.

1. ***Studying the possibilities for clearing the entire 470–862MHz band, with the possibility of more assertive actions (see below) at a later stage***

   An initial step could be to flag up the possibility of band clearance and initiate investigations on the feasibility of clearing high-power DTT and the scope and value that could be offered by new uses. It would be primarily the responsibility of Member States to conduct their own research into the feasibility of ending high-power DTT; however, some EU-level guidelines and research may be beneficial to help compare and review their conclusions. A deadline for reporting the results of the studies would be required, but there would be no requirement at this stage for a provisional clearance date or indeed any certainty that this work would lead to the removal of the DTT platform.

   The main advantage of studying the potential impact and scope for high-power DTT clearance is that it should mean Member States are much better prepared for the next cycle of use for the 470–862MHz band for the DSO. However, if this action is initiated too soon, there is a risk that it may unduly discourage investment in DTT, which could either unnecessarily weaken the DTT platform or weaken the scope for other less radical options, such as the introduction of a second sub-band. Given the current level of investment in DTT and scope for further technological upgrades, it may be premature to start discussing band clearance. Rather, such investigations need only be initiated within a timeframe that provides sufficient notice to plan for alternative DTT provision and identify mechanisms for allocating spectrum to new uses; a period of approximately ten years may be sufficient.

2. ***Directing Member States to plan for possible clearance of the entire band under a provisional timetable***

   A stronger action would be to identify a provisional timetable for band clearance and direct Member States to develop contingency plans for turning off DTT networks. Such plans might include, for example, ensuring the availability of free-to-view satellite platforms for public-service TV programming channels.

The advantage of this approach is that it would greatly increase the likelihood that, should a political decision be taken to do so, DTT could be cleared across Europe according to a common timetable, thus avoiding the current situation where the gap between those Member States that have and have not completed the DSO in Europe will be more than five years. This, in turn, would improve the scope for making cleared spectrum available for new uses on a coordinated basis across the EU. However, the EU would still retain flexibility over its ultimate course of action: a decision on whether to press ahead with band clearance and/or to delay the timetable would not need to be taken until the planning exercises are complete.

Even more so than our action 1 above, a major concern with this action is the interaction with possible plans to adopt a second sub-band. Except in the very long-term, the options to adopt a second sub-band or to clear high-power DTT completely from the band are probably substitute actions rather than consecutive steps (for the reasons described in the introduction to these actions, above). This suggests a possible case for parallel preparations for the clearance of either a second sub-band or the whole band. However, there is a clearly a danger that uncertainty over the future of DTT created by investigations into band clearance might undermine incentives for investment in DTT technology and topology necessary to facilitate a second sub-band. This implies that unless and until a second sub-band can be ruled out as a viable option, some caution would be appropriate in relation to preparations for band clearance. In this context, setting provisional timetables for clearance may be problematic.

3. ***Requiring all Member States to clear the entire band within a particular timeframe***

This is the strongest possible action in order to clear the entire band of high-power DTT. Such action would provide Member States with plenty of time to thoroughly prepare for such a migration, including upgrading other television platforms (e.g. launching new satellites). However, this option would risk incurring substantial migration costs without any guarantees that new high value uses of the 790–862MHz will materialise.

At present, the case for clearing the entire band of high-power DTT is very uncertain, and is reliant on there being high demand from wireless broadband and other services. Therefore, as discussed above, this action does not seem sensible in the short or medium term. In particular any decision to clear the entire band would be very sensitive and would require a political decision to be taken by Member States. At this time, the economic case supporting such a decision is far from clear or certain. However, over time, the economic case for band clearance as a more radical alternative to a second sub-band could become more certain e.g. if the demand for wireless broadband and new uses substantially increases. Therefore, despite being radical, this potential action should not be discounted in the long term.

14.1.4 Actions concerning services currently offered in interleaved spectrum

The main uses of interleaved spectrum (SAB/SAP and cognitive technologies) are generally more adaptable than DTT or wireless broadband in their spectrum needs. Nevertheless, the Commission needs to consider whether its policies for the digital dividend will support adequate provision of suitable spectrum for these uses. The approach that the EU adopts on the other three options above will clearly have major ramifications for the availability of interleaved spectrum:

- If only the 790–862MHz sub-band is cleared across the EU, there would be a modest reduction in the amount of interleaved spectrum. In this case, we expect that DTT multiplexes would continue to largely use MFN or regional SFN topologies, a by-product of which is interleaved spectrum. Thus, even if existing SAB/SAP deployments were disrupted by this change, there would still be plenty of other spectrum in the band for interleaved uses.

- The clearing of a second sub-band could drastically reduce the amount of interleaved spectrum available. This is for two reasons. Firstly there would be a reduction of over 40% of spectrum available for high-power DTT when compared to today; secondly, our modelling in Section 13 suggests that under this scenario DTT platforms may be upgraded to national SFN topologies in order to avoid significant reductions in capacity. This outcome would impact some interleaved users much more than others. Background SAB/SAP users (both social and commercial), which typically require just a few pieces of equipment (wireless microphones, IEMs, talkback), are unlikely to be affected. However, the other three categories of SAB/SAP users identified in Section 4.1.5 (larger-scale use within fixed sites, special events and tours) may find that there is insufficient interleaved spectrum available to accommodate the large quantity of equipment required for big events. Applications that use cognitive technologies would find that the capacity available in the 470–862MHz band is significantly reduced.

- The clearing of high-power DTT from the entire 470–862MHz band would most likely completely remove all spectrum for interleaved uses, unless either the network topology of the new use created interleaved spectrum, or some of the band was reserved nationally for SAB/SAP and/or cognitive technologies. Clearly, if all interleaved spectrum were removed, this would affect both SAB/SAP and cognitive technologies. If some spectrum was reserved on a national basis the impact would differ by use and user: background SAB/SAP uses would most likely have sufficient spectrum for their needs; the other SAB/SAP users would find that they would no longer be able to provide large numbers of wireless microphones at big events; applications that use cognitive technologies would find that the capacity available in the band would be further constrained.

One issue that spans all of these ramifications is that the growth of cognitive technologies may mean that there is insufficient interleaved capacity for both SAB/SAP and cognitive technologies. Currently there is sufficient capacity for almost all SAB/SAP requirements (the very largest events may demand more pieces of equipment than can currently be provided). However, if applications that use cognitive technologies were to significantly grow then this may no longer be the case.

Clearly this is more of an issue if the 470–862MHz band is cleared of high-power DTT or if a second sub-band is adopted, than if just the first sub-band is adopted.

As discussed in Sections 14.1.2 and 14.1.3, it seems doubtful that the adoption of a second sub-band or the clearance of high-power DTT from the entire band could be viable in the short to medium term. Therefore, unless cognitive technologies appear as a major user of the band, there is likely to be sufficient capacity for the vast majority of SAB/SAP users. However, in the long term, the possible adoption of the second sub-band or the clearance of the band means that availability of spectrum for SAB/SAP is less certain.

In Sections 14.1.2 and 14.1.3 we discuss that it may be desirable to commence some preparations for either/both the adoption of a second sub-band and clearing the entire band of high-power DTT, even though firm decisions to take these actions made not be made for a few years. The reason for this is that there is significant uncertainty regarding the demand for 470–862MHz spectrum from wireless broadband and other new uses in the future. Therefore, by commencing preparations in advance of making firm decisions, clearance of the sub-band/entire band can be implemented quickly once a decision has been made. A side effect of deferring these decisions is that it creates uncertainly regarding the availability of interleaved spectrum in the long term. This may discourage investment in SAB/SAP and cognitive technologies in the meantime. Nevertheless, we note that at the Member States workshop held in April 2009, cognitive technology stakeholders stated that even if all Member States rolled out SFNs for DTT, there is enough time between now and the hypothetical full implementation of SFNs to deploy products and make a return on their investments.

A further consideration specific to SAB/SAP is its status as an existing use of the 470–862MHz band. Therefore, as the availability of interleaved spectrum changes with time, a challenge will be to manage the costs of migration and ensuring continuity of service. This process is complicated by the scope for staged changes to the use of the band (e.g. the transition from one sub-band to a potential second sub-band and/or complete high-power DTT clearance) and uncertainty over this process. A possible solution may be better coordination across Member States of spectrum available for such services.

The options we examine for EU-level action with regard to interleaved spectrum are:

1. ***Encouraging or requiring Member States to make sufficient interleaved spectrum available***

   One option is to either encourage or perhaps require that Member States make a minimum amount of interleaved spectrum available following the DSO. This action would have the advantage of giving interleaved spectrum users and their technology providers certainty that adequate spectrum in specifically identified channels will be available to them for several years following DSO. A second aspect to this approach would be to encourage the majority of SAB/SAP usage to be towards the bottom of the band, critically below the location of a potential second sub-band. This would mean that the majority of SAB/SAP users would be less likely to be affected if the second sub-band were to be adopted at a later stage. Only the largest SAB/SAP users would be affected as they may not be able to provide as many pieces of equipment at their largest events.

However, such action does have downsides. Notably, by reserving interleaved spectrum, SMAs would effectively need to ensure that MFNs and regional SFNs remain the predominant DTT deployment topology, and any move to lower-power SFN technologies could be obstructed. This may be particularly problematic if a second sub-band is adopted in the future, as our modelling suggests that it would be economically beneficial for DTT networks to be upgraded to lower-power SFNs rather than accept a reduction in capacity. Also, while such reservations of interleaved spectrum are in place they may preclude the option to clear high-power DTT from the entire band. It may, however, be possible to reserve some of the spectrum that is made available from the clearance for SAB/SAP and cognitive technologies.

2. ***Encouraging interleaved uses to become more spectrally efficient and/or use less valuable spectrum outside the 470–862MHz band***

   By encouraging interleaved users to either become more efficient in their spectrum use and/or to exit the 470–862MHz band in favour of other spectrum bands, the demand for interleaved spectrum could be reduced. This would enable either the release of more digital dividend spectrum for uses other than high-power DTT or it would facilitate the adoption of lower-power SFNs.

   Specific actions to achieve this for SAB/SAP are discussed in Section 14.2.5 below. Specific actions for cognitive technologies are less obvious and potentially are not as necessary; these are discussed in Section 14.2.6. By their nature cognitive technologies identify and then use frequencies that are not in use by other services. If there is less interleaved spectrum available, cognitive technologies will automatically be incentivised to use the spectrum more efficiently or to use alternative spectrum bands.

In practice, a combination of the above two actions may be possible. Given that the adoption of a second sub-band and the clearance of high-power DTT from the entire band are unlikely in the short term, encouraging or requiring the availability of interleaved spectrum may not be desirable until then. Meanwhile, the use of more spectrally efficient technologies and other frequency bands could be encouraged so that interleaved users are well placed to adapt to a loss of spectrum.

14.2 Sector-specific actions

In addition to the high-level options for action described above, there are a wide range of measures that the EU could adopt that will influence demand for spectrum from specific potential uses. In this section, we explore the options for EU-level action for our seven categories of potential uses:

DTT, broadcast mobile TV, wireless broadband, SAB/SAP, PPDR, cognitive technologies and an innovation reserve.

Demand for spectrum from a particular use may be influenced by measures designed to affect technological change, deployment strategies or the level of demand. To justify EU-level action, there must be some advantage from coordinating these measures across the EU. Therefore, we focus on identifying *sector-specific* measures that are likely reinforce the benefits generated by the high-level options for action. In many cases, it may be necessary to identify the most appropriate high-level actions before it is possible to determine which sector-specific actions are appropriate. However, some actions identified below may be warranted in their own right, regardless of high-level actions.

14.2.1 DTT

It is likely that DTT will be the largest single user of the 470–862MHz band following DSO. The GE-06 agreement provides a coordinated basis for use of the 470–862MHz band for DTT across the EU (and beyond). Based on our questionnaire responses, we understand that most Member States plan to deploy between four and ten DTT multiplexes in the 470–862MHz band. DVB-T technologies have been universally adopted, supporting European economies of scale. Therefore, we have not identified any specific need for additional EU-level coordinated action to support the introduction/continued availability of DTT services across the EU. There is, however, a potential role for coordinated EU action to influence future DTT network topologies and the take-up of more efficient technologies.

As discussed in Section 14.1, national decisions on the extent of and nature of DTT deployment is the most important factor in determining the availability of spectrum for other uses. In order to fully realise the benefits associated with an EU-wide 790–862MHz sub-band, replanning of DTT use is needed in many Members States. The adoption of a second sub-band would also require replanning across all Members States. The replanning approaches adopted will also determine the future availability of interleaved spectrum.

There is a strong European dimension to any replanning exercises for two reasons:

- *Interference management.* High-power DTT transmission generates signals that travel over long distances, so the use of frequencies for DTT in one Member State can sterilise large areas of neighbouring countries. As a result, this may produce a "lowest common denominator" effect: the amount of spectrum in the 470–862MHz band used for DTT across the EU is driven by those Member States that derive the most value from DTT. Coordinated action to adopt more spectrally efficient broadcasting network deployment topologies, could potentially free up spectrum for other uses without compromising the availability of DTT services.

- *Economies of scale in DTT equipment*. The efficiency with which DTT uses spectrum could also be improved by the widespread introduction of new transmission technologies (e.g. MPEG-4 instead of MPEG-2, and DVB-T2 instead of DVB-T) and associated improvements in DTT receivers, particularly in relation to interference rejection. Furthermore, if Member States follow a similar technology path, this will facilitate economies of scale in equipment, which in turn should encourage a faster transition to new technologies.

Regarding interference management, Member States are already working closely together to coordinate spectrum use in the 470–862MHz band. The original GE-06 plan for the band was a result of international coordination. Subsequently, in light of proposals to adopt an 790–862MHz sub-band for new uses, a number of Member States have initiated bilateral and multilateral discussions to replan some of their GE-06 allocations. Thus, even without any action at the EU level, some progress on the further coordination of DTT use can be expected. However, it is questionable whether SMAs by themselves can achieve an efficient and timely replanning of DTT necessary to achieve possible high-level objectives, such as a universal adoption of the 790–862MHz sub-band or the possible introduction of a second sub-band. In particular, two issues with the current replanning approach stand out:

- *Prioritisation of national interests over the European dimension.* Each Member State is necessarily tasked with optimising spectrum availability for its country. If replanning exercises are exclusively conducted through national and multinational negotiations, there is a risk that there is no one involved who is representing broader EU-level interests.

- *Asymmetries in the impact of high-level options*. Decisions on the adoption of new sub-bands may disproportionately impact certain Member States because they happen to have more DTT assignments within those sub-bands. Such asymmetries may lead to some Member States opposing specific band-plans, thus reducing the likelihood of a EU-wide approach. In principle, such resistance may be overcome by high-level intervention designed to oblige Member States to adopt a common approach. However, any such actions may also lessen the ability of such Member States to renegotiate their allocations with neighbours.

Member States vary significantly in their plans for adopting more spectrally efficient broadcasting technologies/topologies, such as MPEG-4, DVB-T2 and SFNs. Uncertainty over these plans raises concerns about timescales and the ability of Member States to reorganise DTT in ways that might facilitate the coordinated availability of spectrum. There is a strong European dimension here, because if some Member States are slower to adopt new techniques, they may compromise the ability of their neighbours to use digital dividend spectrum. Furthermore, uncertainty may also lead to delays in the upgrade cycle for DTT receivers and transmission equipment if manufacturers are not confident about take-up. This in turn would mean that prices for new equipment fall less rapidly, which in turn would make it harder for Member States to make the transition to new technologies, owing to concerns about consumer upgrade costs.

Note that these two elements of a European dimension are linked, as the realisation of economies of scale typically needs to be adopted by a critical mass. If interference management concerns created by some DTT deployment decisions by Member States prevent or restrict their ability to adopt new uses, this may in turn impede critical mass adoption across the EU, potentially affecting the viability of a new use.

Reflecting these concerns, we have identified four areas in which EU-level action could be warranted:

- creating specifications for DTT receivers
- adopting advanced DTT transmission technologies
- coordinating DTT deployment topologies
- brokering of bilateral and multilateral negotiations on DTT replanning.

We discuss each of these areas below and present possible actions for each.

Specifications of DTT receivers

During the Stakeholders' Hearings, participants made reference to the lack of standards/ specifications for the performance of DTT receivers, particularly in relation to interference rejection. Comments were also made about whether MPEG-4 and potentially DVB-T2 technologies should be required in *all* receivers in order to maximise the economies of scale across the EU and to minimise the costs associated with replacing receivers.

In common with the potential actions for adopting of new technologies, we have identified three options for EU-level action in relation to DTT receivers (please note that these options are not all mutually exclusive – option 3 could be combined with options 1 and 2).

1. ***Produce guidelines/require that all sold receivers are MPEG-4/DVB-T2 compatible***

   An EU-level recommendation for the incorporation of these advanced transmission technologies in all receivers would increase the likelihood that such technologies are incorporated by default. Greater supply would lower the costs of migrating to these new technologies, and potentially bring forward migration. Equipment costs may rise initially as a result of the additional complexity of equipment although this should be offset over time by the increased economies of scale. Requiring that all sold receivers incorporate these technologies would provide more certainty to manufacturers and provide the greatest economies of scale.

   However, such action would be against the Commission's technology-neutrality policy. There is a risk that MPEG-4 and/or DVB-T2 are not the optimal choices of technology in the long-run.

2. ***Produce guidelines/require that all sold receivers meet technology-neutral performance specifications***

   An alternative option would be specify minimum performance characteristics that all sold receivers would need to either meet or exceed. These could be the bit rate of each multiplex (set to be equivalent to DVB-T2) or parameters that define the performance characteristics of compression technologies (perhaps equivalent to H.264/MPEG-4 AVC as this is a mature standard and the variant that appears to be gaining momentum across the industry). The advantage of this approach over specifying technologies, is that it enables flexibility in the exact technologies that are used. If other transmission technologies that were more advanced/spectrally efficient than MPEG-4 or DVB-T2 became available, these could be used instead. It is also consistent with the Commission's technology-neutral policy. On the downside, it could diminish the benefits from economies of scale, as there is a risk that two or more technologies could be implemented across Member States.

3. ***Specify minimum interference rejection standards for DTT receivers***

   Minimum standards would include detailed specifications for the minimum interference tolerance/rejection performance of the receivers, including the rejection of signals received in the adjacent channel and image channel (n+9). Currently, manufacturers have no incentive to maximise the interference tolerance in receivers (as they may be penalised as a result of higher component and production costs). The universal adoption of minimum standards could allow more of the 470–862MHz band to be used for uses other than DTT (both within individual Member States and in neighbouring Member States). However, these benefits could only be realised if either all old receivers are removed from the market, or measures to prevent interference to old receivers (i.e. not allowing new uses) are abandoned.

The adoption of advanced DTT transmission technologies

Without any EU-level action, Member States may introduce new DTT transmission techniques, such as MPEG-4 and DVB-T2, over widely differing timeframes. This uncertainty could hinder the development of a single European market for DTT equipment and compromise high-level actions (if adopted) aimed at releasing spectrum for other uses. We have identified two actions that may be considered in order to drive coordinated adoption of new techniques:

1. ***Produce guidelines/require that all Member States adopt MPEG-4 and/or DVB-T2***

   A recommended timeline for the migration to MPEG-4 and/or DVB-T2 technologies could be produced at the EU level. While this would not be obligatory, it could gain momentum, leading to an accelerated adoption of these technologies. We note that the proposed timescale of 2012 for ASO across the EU (as detailed in COM(2005)04) despite not being a mandatory requirement, acquired momentum, resulting in the vast majority of Member States setting an ASO date to meet this target date. If a similar approach was adopted to promote the migration to MPEG-4 and/or DVB-T2, many of the benefits detailed in the third action below may be realised.

   As part of this action, Member States could be requested to share deployment plans for MPEG-4 and DVB-T2. This would benefit equipment manufacturers by increasing certainty over the scale economies that could be realised. Such action may also encourage individual Member States to review and enhance their own plans in order to also reap the spectral efficiency benefits, particularly if a critical mass of Member States committed to EU level target dates for migration.

Requiring Member States adopt new transmission technologies would provide a high level of certainty to industry (in particular to equipment manufacturers) leading to the full economies of scale being realised from a single European market. Such widespread adoption could accelerate the creation of a 'second digital dividend' across Europe, freeing additional spectrum for new uses. However, obliging all Member States to adopt a common timeframe may be detrimental to some suppliers and consumers in some Member States, as they may be obliged to replace their existing equipment sooner than anticipated. Again such action would be against the EU's technology-neutral policy.

2. ***Produce guidelines/require that all Member States adopt transmission technologies that meet technolog- neutral performance specifications***

   As above for receiver specifications, it is not certain that either MPEG-4 and particularly DVB-T2 are/will remain the optimal choice of technology and it is possible that the optimum technology may vary across individual Member States. Therefore, specifying minimum performance characteristics (potentially equivalent to MPEG-4 and DVB-T2) may be preferable. This would allow other technologies to be used, as long as they met or exceeded the minimum performance specified.

Note that the high-level option/s chosen (as described in Section 14.1) may influence the need for action regarding DTT transmission technologies. Implementing a second sub-band throughout the EU, and to a lesser extent implementing just the 790–862MHz sub-band, is likely to incentivise Member States to upgrade their DTT networks to MPEG-4 and DVB-T2. This may be more effective than action to solely achieve the goal of improving DTT efficiency.

Any action to encourage a migration to advanced transmission technologies, such as MPEG-4 and/or DVB-T2, will have to consider legacy issues, i.e. existing MPEG-2 and DVB-T receivers becoming obsolete. Therefore, the cost of replacing all legacy receivers should be taken into account when evaluating options for action.

DTT deployment topologies

Member States vary in their plans for the widespread adoption of national SFNs. Although we believe that it is unlikely that national SFNs will be used exclusively across Europe, owing to the need for regional content and coordination at borders, significant efficiency gains could be realised through greater use of SFNs. This will require extensive multilateral coordination between neighbouring countries.

We have identified two options for EU-level action to promote the coordinated use of national SFNs:

1. ***Produce guidelines on the timeline for wider adoption/deployment of national SFNs***

   A recommended timeline for wider deployment of national SFNs could increase the scope for a coordinated replanning of the 470–862MHz band across several Member States with the resulting benefits (and costs) as per requiring national SFNs, discussed below. As discussed above, recommended timelines can build their own momentum but also allow Member States flexibility not to conform if they have specific domestic reasons for adopting another approach.

   As part of this option Member States could be requested to share deployment plans for national SFNs. This would enable Member States to reconsider their own plans, particularly in light of the plans of neighbouring Member States. This may lead to the faster adoption of national SFNs and thereby the more rapid introduction of new services (and/or additional DTT multiplexes) using dividend spectrum.

2. ***Require Member States to more widely adopt national SFNs including specific timelines***

   Member States could be required to adopt the use of national SFNs within a specific timeline. This could either be for all DTT multiplexes or (more realistically) for a subset of multiplexes, allowing the remaining multiplexes to continue to be deployed using MFNs in order to provide regional content. This action would assist the coordinated replanning of frequency assignments across Member States as all parties would be required to find a solution. Such widespread adoption could accelerate the creation of a second digital dividend across Europe.

   Such benefits must be weighed against the potential additional costs for individual Member States from replanning their DTT networks. Costs may include the need for new broadcasting transmitter sites; the realigning and/or replacing of rooftop aerials; and the costs associated with the frequency replanning processes (including negotiations on assignments). Finally, to the extent that adoption of national SFNs leads to changes in the structure of multiplexes and availability of TV programming channels, especially on a regional level, there may be concerns about the loss of value to consumers and external value/public policy concerns.

Again, as outlined in the options for the adoption of advanced DTT transmission technologies, the implementation of a second sub-band throughout the EU may effectively incentivise Member States to upgrade their DTT networks to national SFNs. If so, the actions as outline above may not be required.

Brokering bilateral and multilateral negotiations on DTT replanning

Measures to free up spectrum across Europe for new uses may require significant replanning of DTT between Member States. This is particularly true if measures are aimed at releasing a second sub-band. As discussed above, there may be doubts about the ability of Member States to make the necessary agreements, particularly with neighbouring non-EU countries, within desirable timescales without some EU-level coordination. There may also be concerns that other high-level measures – for example, mandating the clearance of high-power DTT in particular sub-bands – may exacerbate asymmetries between Member States’ positions resulting from uneven GE-06 assignments.

These problems suggest a possible role for the Commission or other European bodies, to play a more active role in promoting and brokering negotiations between Member States, as well as with non-EU countries. In this context, the Commission needs to be careful that high-level actions aimed at promoting the efficient adoption of new uses do not undermine incentives for countries to coordinate their DTT allocations in a fair and efficient way.

14.2.2 Broadcast mobile TV

Broadcast mobile TV had been identified as a leading potential use of digital dividend spectrum. However, over the last 18 months, interest in this use has deteriorated. This is primarily owing to concerns about consumers’ willingness to pay for mobile TV. Further this service can be delivered, perhaps more cost-effectively, via wireless broadband connections or through a satellite broadcast network.[184] Uncertainty over the availability of digital dividend spectrum across Europe may also be a factor in this diminishing support. It is apparent that the case for developing handsets may be significantly affected by the scope for economies of scale in equipment availability across Europe. There may also be benefits for producers and consumers from European coordination to facilitate international roaming and manage cross-border interference.

We have not identified any strong national or EU public policy rationale for either intervention to promote demand for broadcast mobile TV. Rather, it would appear that decisions on whether to deploy this service are best left to the market, which should be better placed than regulators to judge whether consumer demand will be sufficient to justify investment. There is, however, a potential case for intervention to support the availability of spectrum for broadcast mobile TV, which would reduce uncertainty related to economies of scale, roaming opportunities and the interference environment.

The primary concern regarding broadcast mobile TV appears to be economies of scale, although enabling greater roaming opportunities may be a secondary benefit. However, these benefits appear modest as content is generally aimed at domestic markets.

[184] Broadcast mobile TV services can also be provided through hybrid satellite and terrestrial networks e.g. based on the DVB-SH standard.

It is likely that the majority of broadcast mobile TV enabled devices will be integrated within cellular phones or wireless broadband devices, for which implies economies of scale are crucial. Thus, it is important that devices are common across a significant number of Member States (alternatively, economies of scale could be achieved by using devices common to other large markets, such as the USA, but opportunities for this appear limited). Devices incorporating broadcast mobile TV technologies (such as DVB-H, which has been backed by the Commission and has been deployed in a number of Member States, e.g. Finland, Germany and Italy), tune over large portions of the 470–862MHz band. The notable exception is that for devices integrated with mobile technologies using the 900MHz band, frequencies below 750MHz are preferred, in order to prevent interference between the two bands.

Thus, in order to realise economies of scale for broadcast mobile TV it is important that a common frequency range is used by Member States, but this could cover a large portion of the 470–750MHz range. There is a trade-off between the size of the tuning range for broadcast mobile TV and device costs. A large tuning range means that more costly or larger components are required within the device. If the tuning range was limited, device costs would be reduced and devices could potentially be smaller. In this context, it is important to note that broadcast mobile TV would not necessarily require cleared spectrum. It can be deployed in Member States using their existing DTT allocations e.g. in place of a DTT multiplex.

Given that mobile broadcast TV devices could potentially tune across much of the 470–862MHz range and can potentially be fitted into the band alongside DTT, a coordinated European approach may not be essential. However, measures to coordinate the range of frequencies to be used for broadcast mobile TV could assist the business case for this service as it may help to reduce equipment costs. Accordingly, we have identified one possible option for action designed to support the deployment of broadcast mobile TV:

1. ***Produce guidelines on the range of frequencies that could be made available for broadcast mobile TV***

   A recommended common frequency range for broadcast mobile TV could be developed. This range could be wide, incorporating large parts of the 470–750MHz range, reflecting the tuning range of equipment. Member States could choose to allocate spectrum within this range to broadcast mobile TV, or at least make spectrum available on a service-neutral basis such that broadcast mobile TV has the potential to access it.

   The advantage of this action is that it could provide certainty to manufacturers regarding the specification of equipment, potentially reducing device costs. However, identifying a suitable range of frequencies may be challenging. If the range is set too narrowly, some Member States may be discouraged from making any spectrum available to broadcast mobile TV owing to conflict with their GE-06 assignments for DTT. However, if the range is too broad, there is a risk that some Member States’ choice of frequencies for broadcast mobile TV deployment may inhibit the scope for identifying common blocks of contiguous frequencies that could be cleared to adopt a second sub-band.

In this context, it is apparent that there is a potential conflict between high level actions that seek to hold open options for a common second sub-band and actions designed to identify common frequencies suitable for broadcast mobile TV. Consequently, coordination between action regarding a second sub-band and on identifying common frequencies for mobile TV appears appropriate. Realistically, this would only be possible at an EU level. If action is pursued in both areas, then mobile TV would benefit from a decision on what frequencies might be identified for a second sub-band. For example, a decision to develop an option for a second sub-band at 694–790MHz could be complemented by a decision to promote broadcast mobile TV in frequencies from 470–694MHz, alongside DTT.

14.2.3 Commercial wireless broadband

In Section 9.1 we identified wireless broadband as the most economically valuable alternative to DTT for the digital dividend spectrum. There is a strong European dimension relating to the provision of wireless broadband using digital dividend spectrum as a consequence of:

- economies of scale being key to the provision of consumer equipment (e.g. mobile terminals)
- the importance of cross-border roaming
- the scope for DTT transmissions in neighbouring Member States to prevent the use of the same frequencies for wireless broadband services across large areas of a Member State
- the possible role of wireless broadband in achieving the EU policy goal of universal high-speed broadband availability under the i2010 objectives.

The options for action to make spectrum available for wireless broadband are included in our high-level options to adopt an 790–862MHz sub-band and a second sub-band. Under current market conditions, we anticipate that FDD wireless broadband would be the sole, primary use for the 790–862MHz sub-band and, along with TDD wireless broadband systems, would also be a leading potential use for the second sub-band. Therefore, even if individual Member States adopt technology-neutral award processes, the likely outcome of making such spectrum available for new uses would be the coordinated take-up of wireless broadband.

Instead, we focus on concerns over the flexibility of wireless broadband systems and the challenges this creates for EU coordination. We then identify possible EU-level actions that could ease this problem in the future.

Wireless broadband technologies differ in their spectrum requirements:

- TDD technologies can in principle they can be fitted relatively easily into the digital dividend spectrum. Europe-wide economies of scale and roaming benefits can be realised provided that the frequencies made available in individual Member States fall within the overall tuning range of the equipment (even if the individual frequencies vary from Member State to Member State).
- FDD technologies are significantly more challenging to fit into the digital dividend spectrum, owing to the current requirement for a fixed duplex spacing between base transmit (downlink) and mobile transmit (uplink) frequencies. This means that the allocation of different pairs of frequency channels in different Member States would not be compatible with producing standard equipment (e.g. mobile terminals) across Europe. Hence this would prevent the economies of scale and roaming benefits from being fully realised.

The relative inflexibility of FDD systems poses a challenge to the EU's preferred approach of allowing the market to identify the optimal use of radio spectrum. Firstly, for the 790–862MHz sub-band, the favoured paired band plan is highly specific to FDD technology, which makes it complicated to develop a primary award that could balance FDD users with other uses fairly. Secondly, the requirement for paired frequencies to use fixed duplex spacing means that it is not possible simply to add additional frequencies below the 790–862MHz sub-band – a whole new sub-band(s) would need to be created. Thirdly, if additional sub-bands were created, then the same concerns about inflexible FDD band plans would again arise.

If more frequency agile FDD systems could be developed (i.e. systems with variable duplex spacing), or if these could be superseded by TDD systems without sacrificing performance or cost effectiveness, then coordinating use of spectrum across Europe may be much more straightforward. In particular, it would be much easier to have award process in which different technologies (e.g. TDD versus FDD) competed with each other for spectrum within sub-bands, and also to have outcomes in which different technologies shared the available spectrum.

We have identified two possible actions that might be adopted to encourage the development of more flexible wireless broadband technologies:

1. Encourage research into frequency agile wireless broadband systems

The Commission could encourage manufacturers to invest in and adopt more frequency-agile technologies, such as FDD systems that could operate with a variable duplex. The most basic level of action might be to publish papers calling for the adoption of such technologies, potentially backed by research into the feasibility of such systems. On its own, however, this may not create strong enough incentives for users to adopt such technologies. Indeed, one possible barrier to adoption is that incumbent operators may actually prefer less flexibility, as this limits spectrum available for wireless broadband and may act as a barrier to entry.

2. Prioritise access to spectrum for frequency-agile systems

A stronger action would be to consider measures that prioritise frequency-agile systems when making available new spectrum. There are a variety of measures that could be taken, ranging from adopting band plans that favour frequency-agile systems to excluding inflexible FDD uses from bidding for spectrum. Given the strong business case for existing FDD technology for the 790–862MHz sub-band, this is not a viable option for this sub-band. However, it might be an option for future sub-bands, provided manufacturers and users are given enough notice.

14.2.4 Wireless broadband for public protection and disaster relief (PPDR)

The Commission’s 2008 Communication on PPDR[185] stated that “reserving bandwidth for communication in emergency services” should be considered. Subsequently, CEPT Working Group FM has issued a questionnaire to SMAs regarding future spectrum requirements for PPDR. However, there does not appear to be any advanced policy for using digital dividend or other low-frequency spectrum to offer a wireless broadband service for PPDR. At the Stakeholders’ Hearings it was noted that some Member States have recently deployed new emergency service communications systems and are therefore unlikely to invest in new systems in the near future. It was also noted that satellite providers may soon be able to offer such a service using the 2GHz band. As a result the need for a EU-wide wireless broadband network for PPDR using digital dividend spectrum is unclear.

If there was demand for such a network there are three potential sources of a European dimension:

- economies of scale
- the need for international interoperability
- management of cross-border interference.

[185] COM(2008)130 (5 March 2008), “On Reinforcing the Union's Disaster Response Capacity”.

Economies of scale are particularly important for bespoke PPDR systems. It is unlikely that the deployment for such a network would be cost effective for a single Member State, particularly smaller ones. Moreover, dedicated, bespoke networks are preferable for PPDR systems as commercial technologies are not designed to meet their stringent reliability requirements. Interoperability would also be a key feature, as a primary purpose of replacing national systems with a Europe-wide system would be to allow emergency services to work across borders. As a PPDR system is essentially a wireless broadband network, operators would face the same needs to coordinate cross-border interference issues as for commercial wireless broadband networks.

We have identified two options for EU-level action that might be considered if a clear need for a PPDR wireless broadband network is established.

1. ***Produce guidelines on, or require that Member States use of, part of the 790–862MHz sub-band for a PPDR system***

   For those Member States wishing to allocate digital dividend spectrum for a PPDR system, guidelines could be developed on which specific frequencies should be used and when they should be made available. One option would be to identify part of the 790–862MHz sub-band for PPDR, as this spectrum could be potentially available in many Member States from 2012. A stronger step would be to require that all Member States make a common part of the 790–862MHz sub-band available for PPDR systems.

   By using the 790–862MHz sub-band, a PPDR system is likely to be protected from interference from high-power uses in other Member States. Further, it is likely that the sub-band may be harmonised for wireless broadband technologies such as UMTS, LTE or WiMAX. A PPDR system could take advantage of the economies of scale of these technologies, although the scope for this may depend on the extent to which commercial technologies can meet the stringent standards required for PPDR.

   A major drawback of this approach is that allocating PPDR to the 790–862MHz sub-band would reduce the spectrum available for commercial operators (unless it is possible to enlarge the sub-band), thus reducing both the number of possible networks using this spectrum and the demand for commercial handsets across Europe. This implies a high opportunity cost, both directly through displaced commercial use and indirectly due to a likely reduction in economies of scale for wireless broadband using this spectrum. It also appears that given the uncertainty over the immediate case for a Europe-wide system, it’s likely that the adoption of this system across Member States would only be partial, which may compromise the cost-effectiveness of equipment and scope for interoperability. This may be true even if spectrum is set aside exclusively for this use.

   Overall, the 790–862MHz sub-band may also not be the best choice of spectrum for a PPDR system. We understand that operators would probably prefer frequencies closer to 470MHz, so that systems could be rolled out using the base station sites currently used by some national systems which operate in the 400MHz range.

2. ***Produce guidelines on, or require, Member States to use an alternative sub-band for PPDR***

   Guidelines could be developed to allocate an alternative sub-band for PPDR (including a band plan, a timescale over which the sub-band should be made available, etc.). As above, a stronger step would be to require that Member States adopt an alternative sub-band for PPDR. In order to minimise adjacent channel interference (ACI) between two-way, medium-power networks (including a PPDR system) and DTT, an obvious place for such a sub-band would be the spectrum immediately beneath the proposed 790–862MHz sub-band. However, when considering roll-out costs, spectrum at the lower end of the band may be preferred.

   This action has many of the same advantages and disadvantages as the first, with the exception that there is no impact on the amount of spectrum available for commercial wireless broadband in the 790–862MHz sub-band. Outside of this sub-band it may not be possible for PPDR take advantage of the economies of scale of commercial networks; however, this benefit may be more than offset by lower roll-out costs if systems are rolled out at 470MHz.

   Promoting a PPDR system outside the 790–862MHz sub-band would also have an impact on DTT. In particular, spectrum immediately above 470MHz is very heavily used for DTT, so extensive replanning may be required to create availability for PPDR. It would be very challenging to achieve this reorganisation in the short term, but it might be plausible (as part of a broader initiative in the medium or long term) to introduce a second sub-band or even clear high-power DTT from the band. More generally, given the current uncertainty over European demand for spectrum for this use, it may be appropriate that any decision on PPDR is included in a wider review of the value of new uses in the context of a medium to long term decision on freeing up addition spectrum for new uses.

14.2.5 Services ancillary to broadcasting and programme making (SAB/SAP)

Proposals to reorganise the 470–862MHz band and introduce new uses will have a significant impact on the availability of spectrum for SAB/SAP. Many users may be obliged to vacate their existing frequency channels, requiring them to replace current equipment (which typically can only tune across two or three adjacent 8MHz channels). At present, there is little coordination of SAB/SAP deployments across the EU, as users are allocated spectrum that is not used by analogue TV or DTT in their own country. This means that economies of scale in equipment production may not be being realised fully across Europe. The enforced reorganisation of this use may however provide an opportunity for new benefits to be realised through EU-level coordination of spectrum availability, which may more than offset the costs of replacing existing equipment.

Some economies of scale could be realised if Member States identified either single 8MHz channels or groups of adjacent 8MHz channels as suitable for SAB/SAP, and each dedicated at least one of these nationally to SAB/SAP. Such economies of scale would be particularly beneficial to background users (both social and commercial) as all of their equipment could operate in these national channels. Touring users would also benefit as they could use these channels at all of their event locations. Larger scale users within fixed sites and special events would also benefit, but to a lesser degree, as they require equipment that operates simultaneously over multiple channels, so would still require access to spectrum in other channels and equipment that can use other frequencies. Arguably, creating common nationally-available channels would also be particularly advantageous in stimulating social use, as this is most sensitive to equipment costs. However, given that existing business practice suggests that it is viable to build equipment aimed at a limited number of national markets, and given the relatively small volume of equipment sold each year (at least when compared to mass market uses such as wireless broadband), the total benefits from such economies of scale may be modest compared to mass market uses. Furthermore, some large-scale events require equipment operating simultaneously over multiple frequencies, so they would still require access to spectrum at other frequencies and equipment that can use other frequencies.

There may also be modest benefits from roaming. At present, professional SAB/SAP users would typically require different equipment in order to provide services across several Member States. If the same groups of channels are used across Member States, then it would be cheaper to deploy across multiple Member States. For example, touring companies could extend their shows across national boundaries, an events company from one Member State may be better placed to bid for a contract in a neighbouring Member State, and broadcasters may find it easier and cheaper to cover news events in other Member States.

More generally, many Member States are currently addressing the challenge of where to reallocate SAB/SAP users. At least seven Member States have dedicated channels for SAB/SAP, some of which are located within the proposed 790–862MHz sub-band (Channel 63 in the Netherlands, and Channel 69 in Ireland, Malta and the UK), so must be moved if the sub-band is to be adopted. In the absence of any EU-level coordination of this relocation process, there is a risk that Member States move domestic SAB/SAP users to channels that ultimately conflict with plans for a second sub-band. If this happens, plans for a second sub-band may be seriously weakened or SAB/SAP users may have to moved again, implying unnecessary additional costs.

One way of avoiding conflict with future policy is for Member States to target spectrum within the 470–862MHz band that cannot be used for wireless broadband or DTT, owing to interference constraints. If the 790–862MHz sub-band is adopted, a possible option is the centre gap between uplink and downlink (possibly 821–832MHz) that would be created if an FDD band plan is adopted. However, the SAB/SAP community have concerns over the feasibility of this, due to possible interference from wireless broadband devices, and because the nearest interleaved spectrum to this centre gap is further than the tuning range of most equipment. This means that equipment could not be purchased that operates over both the centre gap and interleaved spectrum. Meanwhile, the UK is considering dedicating Channel 38 to SAB/SAP; this channel is currently used for radio astronomy in the Netherlands, preventing medium or high-power use in large areas of adjacent countries.

More generally, as discussed in our high-level options, the long-term use of the 470–862MHz band by SAB/SAP is threatened by various reforms that may reduce the availability of interleaved spectrum, such as the deployment of national SFNs for DTT. Unless, SAB/SAP can also become more efficient in the way it uses spectrum, it may be increasingly constrained.

We have identified five options for EU-level action that may help to generate a single market for SAB/SAP equipment, and reduce the costs associated with the relocation of services:

1. ***Request that Member States share plans regarding the relocation of dedicated frequency channels for SAB/SAP***

   As discussed above, a number of Member States will need to relocate their dedicated frequency channels in order to clear the 790–862MHz sub-band. By sharing their plans for thee relocations, Member States may be able to coordinate to a common range(s), thus maximising economies of scale.

2. ***Produce guidelines on a common set of frequency channels to be dedicated for SAB/SAP use***

   These guidelines could highlight one or more sets of contiguous frequency channels that could be dedicated for SAB/SAP use. Member States wishing to change the location of nationally-available frequency channels in order to make the sub-band available, may take the opportunity to move to one or more of these common channels. Member States that currently do *not* have such a dedicated channel could choose to create one in this frequency range to take advantage of the economies of scale. The centre gap of the 790–862MHz sub-band may be one option for the location of these channels, given that this spectrum may have a very low opportunity cost in Member States that introduce wireless broadband in the 790–862MHz sub-band.

   This option should increase economies of scale for SAB/SAP equipment in these chosen channels and provide greater certainty for equipment manufacturers to invest in the development of future equipment. Such guidance could also prevent a situation where unilateral Member State action inhibits future options for adoption of a second sub-band.

3. ***Requiring Member States to make a dedicated channel available for SAB/SAP***

   This action would result in each Member State being required to make at least one 8MHz channel, from a common set of contiguous spectrum channels (ideally just two or three), available for SAB/SAP on a dedicated basis. Again, use of the centre gap in the proposed 790–862MHz sub-band could potentially be used. This would generate the maximum economies of scale and certainty for equipment manufacturers. However, many Member States do not currently have dedicated nationally-available frequency channels for SAB/SAP. This indicates that such a dedicated channel may not be beneficial in all Member States. Depending on the location of this channel/s, there may also be a significant opportunity cost in terms of the displaced uses.

4. Encourage the migration of SAB/SAP to alternative frequency bands

SAB/SAP need not use the 470–862MHz band. Spectrum bands outside of 470–862MHz have also been identified for digital wireless microphones and IEMs. Most notably the 1452–1559MHz and 1785–1800MHz bands have been proposed by CEPT. For talkback, equipment is available in other frequency bands in many Member States including VHF Band 1, VHF mid-band and 440–470MHz.[186] Further, according to CSMG[187], technologies could be used in frequencies above 3GHz to provide equivalent functionality to wireless microphones, IEMs and talkback. In particular ultra-wideband technologies may be used.

These alternative frequency bands are typically less heavily used than the 470–862MHz band. The opportunity cost of relocating SAB/SAP use to these bands may therefore, be less than the incremental deployment of SAB/SAP in the 470–862MHz band. This approach may not realise any economies of scale but may still be desirable if conflict between SAB/SAP and new uses of digital dividend spectrum cannot be adequately resolved in some or all Member States.

5. Support the development of digital technology for SAB/SAP

The development of digital technology for the SAB/SAP sector has lagged behind other wireless technologies, such as mobile telephony and television. This is probably due to a combination of factors, including the current widespread availability of interleaved spectrum, the potential higher cost of digital equipment and technical concerns about the effects of digital equipment for certain functionality. The change in availability of interleaved spectrum may encourage new investment in digital technology. If so, this would greatly improve the ability of the sector to maintain and even expand its range of services. In this context, there might be a role for intervention to accelerate the process of switching to digital services.

Intervention could take a number of forms. For example, support for research & development might provide an incentive for the development of more spectrally efficient SAB/SAP technologies. Alternatively, charging incentive prices for SAB/SAP spectrum or setting a date for DSO are possible incentives to drive change. As this problem is common across the EU, coordinated action at the EU level may be the most appropriate way of supporting change.

[186] VHF Band I is 55.75–68MHz; VHF mid band is 121–174MHz.

[187] CSMG (November 2008), "Potential for more efficient spectrum use by wireless microphones".

14.2.6 Cognitive technologies

Cognitive technologies are still in development, but still have the potential to generate significant value. By transmitting using spectrum that is detected as unused, cognitive devices have the potential to increase the overall efficiency of spectrum use. Although such devices might be capable of tuning across the entire 470–862MHz band, it is likely that they would make particular use of spectrum interleaved with DTT (white space).

The principal source of a European dimension regarding cognitive technologies is economies of scale. As the applications that use cognitive technologies may vary widely, the requirements for economies of scale may do as well. However, certain applications, such as wireless local area networks, may be potential mass-market products that depend on economies of scale. Some applications may also benefit from international roaming.

As applications using cognitive technologies would tune over wide frequency ranges, it would not be necessary for exactly the same frequencies to be available across Member States in order to achieve economies of scale. It should also be noted that cognitive technologies might be used in major market in other parts of the world, such as the USA. Therefore, further economies of scale may be achieved by aligning frequency choice with these markets.

A key issue for the potential effectiveness of cognitive radio systems in the 470–862MHz band is the availability of interleaved spectrum. Under existing Member States’ plans for the band, there will be very large amounts of interleaved spectrum available. However, this situation may change if DTT providers increase their use of SFNs and/or a second sub-band for non-DTT uses is introduced. As outlined in Section 14.1.4 in relation to high-level approaches toward interleaved spectrum, we believe that the amount of interleaved spectrum is unlikely to reduce significantly in the medium term. This view was echoed by a stakeholder from the cognitive technology community at the Stakeholders’ Hearings, who argued that there is enough time between now and the hypothetical full implementation of SFNs to deploy products using cognitive technologies and make a return on investment.

Consistent with our high-level options for interleaved spectrum, we have identified two potential options for action relating to cognitive technologies:

1. ***Develop common guidelines regarding regulatory measures for cognitive technologies***

   The introduction of cognitive technologies will be discussed at WRC-11 under agenda item 1.19. This will include the technical parameters and regulatory conditions under which cognitive technologies should be introduced. In particular, decisions need to be made regarding which technical approaches (detection, geolocation databases and beacon reception) will be permitted, as well as the technical specification required of the chosen approach. In order to maximise the benefits from economies of scale it may be advantageous for Europe to adopt the same technical parameters as other major markets, in particular the USA. In November 2008, the FCC decided to allow cognitive technologies to use interleaved spectrum, devices may be required to use both spectrum detection and geolocation.

If Member States can agree these parameters and conditions this is likely to encourage the development of a single market for these technologies, leading to economies of scale. It would also provide increased certainty to equipment manufacturers regarding the technical specifications and potential market size, leading to faster time to market for this technology.

2. ***Produce guidelines or require Member States to adopt a common frequency range(s) for cognitive technologies***

   Europe could produce guidance on or require Member States to use a common frequency range(s) for cognitive technologies in the 470–862MHz band, along with timescales for when such cognitive technologies could make use of this spectrum.

   Guidance alone should be sufficient to provide certainty to equipment manufacturers over the tuning range that their equipment should support. It may also encourage the creation of a single European market, thus facilitating economies of scales and enabling roaming. However, it is not guaranteed that Member States would follow such guidelines, thus there is a risk that economies of scale and roaming will not be realised.

   A requirement for specific frequency ranges would provide greater certainty to equipment manufacturers, and would increase the scope for rapid realisation of benefits from economies of scales and roaming. In this case, a requirement may not have any significant opportunity cost providing cognitive radio is only required as a secondary use; and it is confirmed that cognitive radio systems will not interfere with other uses.

Note, that none of these actions provide certainty over the future availability of interleaved spectrum. As cognitive radio is a secondary use, even requiring its use in digital dividend spectrum does not guarantee the sufficiently long-term availability of spectrum for cognitive applications to be viable. As discussed in our high-level options, the scope for investment in developing and launching cognitive applications would be enhanced if greater certainty could be provided over future plans for adopting a second sub-band, deploying national DTT SFNs and the potential for long-term clearance of high-power DTT. This may, however, conflict with preferences to keep such high-level options open in the medium term, unless and until new information emerges on the value of making further spectrum available for new primary uses.

14.2.7 Innovation reserve

A further potential use for digital dividend is an innovation reserve outlined in Section 4.1. This would involve spectrum being either reserved specifically for experimental purposes such as trialling new technologies, or held in reserve for new uses that may emerge in the future.

We see no particular requirement for coordinated adoption of spectrum for experimental purposes across the EU. It seems reasonable to suppose that experiments can continue to be facilitated at a national level, for example using interleaved spectrum. Moreover, Member States could decide individually to set aside some spectrum that would otherwise have been used for DTT for experimental purposes. More generally, reserving spectrum across the EU would have a high opportunity cost with no guarantee of benefit.

There is the potential for Member States not making digital dividend spectrum available if there is concern that an immediate award process would not be effective in realising the most valuable long-term uses. Most obviously, this concern would apply if there are potential uses whose value is heavily dependent on EU-wide availability in order to realise economies of scale or provide certainty over interference compatibility. This relates to our high-level options, which consider measures to adopt a second sub-band. Unless and until the EU rules out the option of a second sub-band and identifies appropriate frequencies, there are benefits from Member States not releasing additional spectrum that might compromise EU coordination. As these arguments are covered in our high-level options, we do not consider any specific options for action in relation to an innovation reserve.

15 Economic evaluation of the proposed options for action

In Section 14 we identified two broad categories of option for EU-level action regarding use of the 470–862MHz band:

- *high-level actions*, which influence the availability of spectrum
- *sector-specific actions*, which may influence relative demand for spectrum from potential uses.

Decisions on high-level actions will influence how spectrum is allocated to different uses over the short, medium and long term. Sector-specific actions could be adopted to reinforce the positive effects of high-level actions and/or to reduce any undesirable side-effects.

We identified four high-level options that could be pursued. These are:

- adopting the 790–862MHz sub-band, suitable for wireless broadband deployment across Europe
- adopting a second sub-band, suitable for uses other than high-power DTT
- promoting the long-term availability of the entire 470–862MHz band for uses other than high-power DTT
- encouraging use of interleaved spectrum within the 470–862MHz band.

In each case, we identified a number of possible actions that could be taken now at the European level to realise these options in the short, medium or long term, as applicable. Note that these actions could lead to the adoption of the above options under a variety of possible timeframes. Depending on when the implementation of the first three options is considered, they may be either alternative options or consecutive steps. The actions relating to the fourth option will be significantly affected by decisions regarding the first three.

In this section we review these high-level options and the associated actions in the light of the results of our economic valuation exercise in Section 13. Where there is strong evidence that a particular option is likely to produce significant value, taking action *now* may be desirable. Where evidence supporting an option is weaker or uncertain, actions that *defer* decisions may be preferable.

Having established a position on the high-level approach, we then evaluate the sector-specific measures. This evaluation is based on quantitative or qualitative socio-economic analysis. For each potential use, our primary objective is to identify which measures reinforce the preferred high-level actions. However, in some instances sector-specific action may be justifiable in its own right. Care needs to be taken in reviewing sector-specific action so not to deviate without good reason from the general EU policy position of technology and service neutrality.

15.1 High-level options

In this section we evaluate the high-level options identified in Section 14.1. Note that we have combined the evaluation of two options, adopting a second sub-band and clearing high-power DTT entirely from the 470–862MHz band, as these two options are likely to be mutually exclusive. Specifically, any decision to adopt a second sub-band rather than clear the whole band implies a parallel decision to invest in reorganising DTT within the band, which in turn implies that high-power DTT will be viable for at least another ten years. Therefore, it is appropriate to consider these options together.

15.1.1 Actions supporting the adoption of a 790–862MHz sub-band (option 1)

In Section 14.1.1 we demonstrated that there is a European dimension regarding the adoption of the 790–862MHz sub-band. EU-wide adoption of the sub-band would enable benefits that would be enjoyed by all Member States including economies of scale, roaming and confidence for manufacturers. It would also avoid high-power DTT transmission by some Member States preventing neighbouring Member States from making the sub-band available for wireless broadband or, potentially, other services. The EU-wide adoption of the sub-band may also contribute to realising EU policy goals, such as bridging the broadband gap. In this section we identified four potential actions in order to support the adoption of the 790–862MHz sub-band:

- maintaining the current policy of strongly encouraging Member States to clear and award the 790–862MHz sub-band, but not imposing formal measures
- reversing the priority regarding interference coordination away from high-power DTT and in favour of wireless broadband
- requiring all Member States to clear the 790–862MHz sub-band and award it on a service- and technology-neutral basis
- requiring all Member States to clear the 790–862MHz sub-band and awarding authorisations for wireless broadband with common technology restrictions and a common band plan.

The results of our economic modelling in Section 13.2, repeated below in Figure 15.1, suggest that EU-wide clearance of the 790–862MHz sub-band would lead to substantial private value benefits under all of the demand scenarios considered (between EUR17 billion and EUR44 billion depending on which demand scenario[188]).

[188] Net present value over 15 years.

Demand scenarios	*Incremental private value relative to the Reference Scenario*
Scenario A *(DTT low, wireless broadband low)*	EUR17 billion
Scenario B *(DTT low, wireless broadband high)*	EUR44 billion
Scenario C *(DTT low, wireless broadband high with a new use)*	EUR44 billion
Scenario D *(DTT high, wireless broadband low)*	EUR17 billion
Scenario E *(DTT high, wireless broadband high)*	EUR44 billion
Scenario F *(DTT high, wireless broadband high with a new use)*	EUR44 billion

Figure 15.1: Private value generated by Scenario 1: Sub-band for non-DTT use introduced at 790–862MHz [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

There is also likely to be public value generated by the adoption of the sub-band, notably from the provision of wireless broadband to rural areas. Although this may be at least partially offset by the loss in public value if the number of DTT programming channels is reduced in order to clear the sub-band. Therefore, EU-level action appears warranted for this option. The question is which action is most appropriate?

Action to simply encourage Member States to adopt the 790–862MHz sub-band may well persuade Member States that have not yet committed to the sub-band, to do so. As a result, a proportion of the EUR17 billion to EUR44 billion benefit identified may be realised. Indeed, during the course of this study, a number of Member States (including Germany, the Netherlands and Spain) have already changed their position, announcing that they *will* support the sub-band proposal. However, non-obligatory action cannot guarantee the EU-wide adoption of the sub-band. We note that at our Member States workshop (Brussels, 15 April 2009), Member States expressed a preference for non-obligatory action to encourage the adoption of the sub-band. This was also the view in the RSPG working group's paper on the digital dividend.[189] However, given the clear economic case, both at a national level and when EU-wide benefits are included (e.g. economies of scale, sterilisation due to interference from DTT), stronger action appears warranted and proportional.

Requiring all Member States to award the sub-band for wireless broadband with common technology restrictions and common band plan may secure the EUR17 billion to EUR44 billion benefit, assuming that the technologies and band plan identified (which we assume would be FDD wireless broadband) meet the future demands of the market. However, there is a risk that such technologies turn out to be non-optimal. Further, this action would be against the Commission's WAPECS concept of service and technology neutrality when awarding spectrum. Overall, these two downsides appear significant enough for there to be little merit in following this action.

189 RSPG position paper on the digital dividend (27 April 2009), RSPG09-271.

An intermediate approach between encouraging the adoption of the sub-band and requiring Member States to allocate it to a specific technology, is to require all Member States to make the sub-band available in a format that enables it to be used for wireless broadband. This action is likely to be just as effective as mandating a specific technology in realising the EUR17 billion to EUR44 billion benefit. Note that this option does not preclude Member States awarding the sub-band specifically for wireless broadband. We understand that this is the intention of some Member States. However, such a deviation from the EU’s service- and technology-neutral policy would need to be justified, and we suggest that Member States are encouraged to award the sub-band on a service- and technology-neutral basis, in accordance with the Commission’s WAPECS principle. This means that if either technologies or services demanded by consumers evolve in the future, there is scope for the use of the sub-band to change in order to meet that demand.

One question remains: by when should all Member States be required to award the sub-band? The economic benefit would be maximised if all Member States were to award the sub-band as soon as possible. However, there are constraints that mean such action may not be possible for all Member States in the short-term (i.e. by 2012). Firstly, Member States that are near EU borders, particularly the eastern border, may find that they are severely restricted in their ability to use the sub-band for wireless broadband, and potentially other uses, by high-power use in neighbouring non-EU countries (notably Russia). We understand that it is unlikely that these non-EU countries will adopt the sub-band before 2015. Secondly, some Member States face significant obstacles to migrating existing DTT use in the sub-band to lower frequencies. For example, Spain has stated that it will only be able to make the sub-band available from 2015. Overall, it appears unreasonable that all Member States should be required to adopt the sub-band before 2015. Therefore, we recommend that Member States are required to adopt the sub-band by 2015. Of course, it may also be beneficial for the Commission to encourage Member States to adopt the sub-band earlier where possible.

When calculating the benefit of adopting the sub-band (Scenario 1 in Section 13.1), we assumed that no high-power use, such as DTT, is allowed in the sub-band. However, if Member States were to award the sub-band on a service- and technology-neutral basis with the current technical restrictions, it may be possible for a bidder to win a licence and then use the spectrum for a high-power use. This would interfere with lower power use in the sub-band in neighbouring Member States, resulting in some of the EUR17 billion to EUR44 billion being foregone. Therefore, it appears reasonable to restrict emissions in the sub-band at Member States’ borders. The restriction should state that emissions at borders should not exceed that of a medium-power use, such as wireless broadband. Note that this restriction would not preclude high-power DTT gaining spectrum in a service- and technology-neutral award, but it would severely restrict the power levels of its transmission near border areas.

Based on current market conditions, we expect that in those Member States that award the sub-band on a service- and technology-neutral basis, most or all of the sub-band in each Member State would be acquired by users intending to deploy wireless broadband using FDD technology. Consequently, it will be necessary for each Member State to hold an award in which a possible outcome is an EU-wide common band plan. At the time of writing the FDD band plan suggested by CEPT (791–821MHz paired with 832–862MHz) appears the most likely candidate for such a band plan. Some Member States may choose to make the spectrum available with only this band plan. Others may decide to use technology-neutral auctions in which the market has a role in determining the band plan. The fact that Member States may take different approaches does not matter provided that wireless broadband bidders can bid in the certainty that if they win spectrum, they will be allocated frequencies consistent with the FDD band plan suggested by CEPT.

Of course, other Member States may choose to directly award the sub-band for wireless broadband use. In these circumstances, in order maximise benefits from economies of scale and certainty for manufacturers, we suggest encouraging these Member States to award the sub-band using the CEPT FDD band plan, although other band plans are not explicitly precluded (e.g. the TDD band plan proposed by CEPT).

Clearance of high-power DTT from the sub-band (and possible clearance from more parts of the 470–862MHz band) will involve substantial investment by the current users to restructure their DTT networks. Since the benefits of clearance will accrue to others (most likely wireless broadband providers), the question will arise as to who should finance these refarming costs. This is a matter for national governments to decide, and we therefore do not address it in our EU-level recommendations. However, as noted in Section 8.3, the fact that adoption of the sub-band is likely to generate public value suggests that there may be a role for public funding.

In light of the above evaluation of the potential actions for the adoption of the 790–862MHz sub-band, we recommend the following course of action.

Recommended action 1:

All Member States are required to clear and award the 790–862MHz sub-band by 2015 in a format that enables it to be used for wireless broadband. Member States are encouraged to award the sub-band on a service- and technology-neutral basis, in accordance with the Commission's WAPECS principle.[190] To support these actions, technical restrictions should be in place to prevent emissions at borders exceeding medium-power thresholds.

Member States are free to design their own award processes, but these should not preclude the possibility of spectrum being used for wireless broadband using paired spectrum channels in line with CEPT's FDD band plan.

Where possible, Member States are encouraged to adopt the sub-band prior to 2015. To facilitate this action, Member States may be requested or obliged to share their plans publicly regarding the adoption of the sub-band.

190 Note that Member States may still directly award the sub-band for wireless broadband use if deviation from the EU's policy of service and technology neutrality can be justified.

15.1.2 Actions to potentially clear further spectrum below 790MHz (options 2 and 3)

The results of our economic modelling in Section 13 suggests that there are demand scenarios in which either adopting a second sub-band or clearing high-power DTT from the entire 470–862MHz band could be economically beneficial.

- If demand for wireless broadband is high, we estimate that adopting a second sub-band would produce an additional EUR17 billion of economic value[191] over and above that generated by the adoption of the first sub-band. This value rises to EUR31 billion if there is also demand for a further new high-value use.

- If demand for wireless broadband is high, we estimate that clearing the entire band would create an additional EUR6 billion of economic value over and above that generated by the adoption of the first sub-band. This value rises to EUR51 billion if there is also demand for a further, new, high-value use.

However, if the demand for wireless broadband is low and demand for a second high-value use does not emerge, then either adopting a second sub-band or clearing the entire band would be detrimental relative to continuing to use this spectrum primarily for high-power DTT.

In terms of public value, the case is likely to be similar. The further clearance of the band could generate additional public value from wireless broadband or future as yet unknown uses. However, the loss of public value from DTT could be higher than if just the first sub-band was adopted, particularly in the case of total clearance of high-power DTT from the band if the public value of DTT cannot be fully replicated on other TV platforms.

Sections 13.1.2 and 13.1.3 identified three types of potential action that may lead to the adoption of a second sub-band and the complete clearance of the 470–862MHz band:

- studying the possibilities for the adoption of a second sub-band/clearance of the entire band, with the possibility of more assertive actions at a later stage

- directing Member States to plan for possible clearance and award of a second sub-band/the entire band under a provisional timetable

- requiring Member States to adopt a second sub-band/clear the entire band within a particular timeframe.

Given that the benefit from either adopting a second sub-band or clearing high-power DTT from the entire band depends heavily on the future demand for wireless broadband/other services, for which there is great uncertainty, *requiring* Member States to implement the sub-band or broader clearance of high-power DTT appears unwarranted. In any case, it is currently unlikely to be politically acceptable in many Member States.

191 Net present value over 15 years.

If, in future, it was thought that either the second sub-band or clearance of high-power DTT was attractive, there would be a lead-time to research and prepare for the possible clearance and award of a second sub-band or the entire band. The tasks would include:

- *Research into the potential adoption of a second sub-band*: the size, frequency location and band plan of the sub-band would need to be agreed.
- *Preparations for the potential adoption of a second sub-band*: existing DTT assignments in the second sub-band would need to be renegotiated before the sub-band could be cleared, potentially a GE-06 style conference may be the most effective way of achieving this. It may also be necessary to upgrade the DTT platform (e.g. to MPEG-4, DVB-T2 and/or SFNs) in order to retain its existing capacity.
- *Research for the potential clearance of the entire band*: the cost and logistics of migrating DTT viewers to an other platform would need to be better understood.
- *Preparations for the potential clearance of the entire band*: existing DTT users would need to be migrated to another platform. In some or all Member States, upgrades may be required to other TV platforms (most notably the satellite platform) in order to maintain a universal free-to-view service.

Therefore, action to research and prepare may be beneficial in the short to medium term, prior to any decision to follow either of these actions, in order to prevent delays in implementation. In Section 13.1.1 we quoted that previous studies have estimated the loss in economic value from delaying the adoption of the 790–862MHz sub-band by one year to be approximately 10% of the total value of adopting the sub-band. Assuming that this ratio holds for the adoption of the second sub-band and the clearance of the band, the cost of a one year delay would be:

- *adoption of a second sub-band:* EUR1.7 billion[192] if the demand for wireless broadband is high, and EUR3.1 billion if there is also demand for another high-value use
- *clearance of the entire band:* EUR0.6 billion if the demand for wireless broadband is high, and EUR5.1 billion if there is also demand for another high-value use.

However, if the above planning and preparations do not begin soon, the delay to the adoption of a second sub-band/clearing the band could be significantly larger than just one year – three or even five years is plausible.

In Section 14, we concluded that the adoption of a second sub-band is unlikely to be viable before the medium term (circa 2018) and that the clearance of the entire band is unlikely to be viable before the long term (2020 and beyond). However, the preparations for these actions could also be lengthy. For the adoption of a second sub-band, once the size, frequency location and band plan of

192 Net present value over 15 years

such a sub-band have been identified, it is conceivable that preparations to clear and award the sub-band could take several years. Meanwhile the migration of DTT to another TV platform could easily take more than five years. Therefore, it would be beneficial that such preparations commence in the short to medium term in order to have the option of implementing these actions in the timescales suggested above.

We recommend that, in the short to medium term (circa 2012–2014), a review is undertaken to decide whether to take preparatory action, and if so, whether to focus on a second sub-band or clearance of the entire band. The review should consider both the likely evolution of demand for wireless broadband/other services, as well as the costs associated with clearance of a second sub-band or the entire band. This approach would provide sufficient time to implement either of these plans in the medium to long term.

For the avoidance of doubt, we suggest that beginning preparations to either adopt a second sub-band or clear the entire band should not commit Member States to actually *implementing* these actions. We expect that further clearance of the band would require political approval. Further, such preparations do involve significant costs (which are taken into account in our modelling). For example, we estimate the EU-wide cost of upgrading DTT networks to DVB-T2 at around EUR10 billion and the creation of free-to-view satellite platforms at EUR26 billion. Given the possibility that future demand for mobile broadband or other uses is not strong enough to warrant the adoption of a second sub-band or clearing the entire band, preparations should not begin until necessary to meet the proposed timetable.

As outlined above, research will also need to occur before the above review, as well as before any preparations for the clearance of the sub-band or the entire band can begin. This includes research to:

- identify and recommend the size, frequency location and band plan for a sub-band below 790MHz
- understand more clearly the logistics and costs of clearing either a second sub-band or the entire band
- understand the necessary upgrades to other platforms (most notably the satellite platform) to offer a universal, free-to-view TV service.

This research could potentially be undertaken by CEPT and, compared to the preparatory actions outlined above, is of relatively low cost. Therefore, in order to meet the timescales for implementation as outlined above, it may be advantageous for such research to be conducted ahead of the above mentioned review and ahead of possible preparatory action for further clearance of the band.

It should be noted that many Member States have either recently committed to the 790–862MHz sub-band and are now preparing for its implementation, or are in the process of evaluating the case for this first sub-band. Such decisions will affect a wide range of stakeholders, not least broadcasters who will experience a reduction in the spectrum available to them. Hence, these decisions are politically sensitive. It is important that any discussion or action regarding the possible adoption of a second sub-band or clearance of the band does not delay the adoption of the first sub-band. Therefore, we recommend that any review of possible preparatory actions for further clearance of the band does not occur before decisions regarding the first sub-band are largely resolved. Also only minimal research, limited to informing this review, should occur during this period.

Our recommended course of action for clearing further spectrum below 790MHz is as follows:

Recommended action 2:

There is insufficient information about future demand for wireless broadband and other services to currently make a decision on whether Member States should be encouraged to clear spectrum in addition to the sub-band at 790–862MHz. However, the possibility of action in the medium-long term to either adopt a second sub-band or to clear entirely the 470–862MHz band should not be ruled out.

We propose that the issue of further band clearance is reviewed again in short to mid term. This review should only take place once decisions regarding the first sub-band are largely resolved. Any review should consider both the likely evolution of demand for wireless broadband and other services, and the costs associated with clearance of high-power DTT and other incumbent users from a second sub-band or the entire band. The review should also consider what subsequent preparations would be required to facilitate the rapid and coordinated implementation of further spectrum clearance across Member States if an EU decision was made to proceed with the second sub-band or total clearance.

Some limited research into the two options for further clearance should be initiated ahead of this review, so as to reduce any future delay in implementation. Such research should: (1) identify the amount, frequency location and band plan(s) for any spectrum to be cleared; (2) investigate the logistics and costs of each option for clearance; and (3) review the measures necessary to ensure adequate provisions of incumbent services using other platforms or spectrum bands (e.g. any upgrades to other platforms necessary to maintain universal free-to-view TV services).

15.1.3 Actions concerning services currently offered in interleaved spectrum (option 4)

As discussed in Section 14.1.4, the Commission needs to consider whether its policies for the digital dividend will support the adequate provision of suitable spectrum for interleaved spectrum uses (notably SAB/SAP and cognitive technologies); we identified two potential actions:

- encouraging or requiring that Member States make sufficient interleaved spectrum available
- encouraging interleaved uses to become more spectrally efficient and/or use less valuable spectrum outside the 470–862MHz band.

Note that the decision on whether to follow these two actions depends heavily on the actions taken regarding the first three high-level options (as given above). Given that in Section 14.1.4 we recommend that no preparatory action is taken in the *short term* to either adopt a second sub-band or clear the entire band, it appears unlikely that these eventualities will occur in the short to medium term. Also, our economic modelling suggests that if only the 790–862MHz sub-band is created, then the widespread adoption of national SFNs is also unlikely. Therefore, there is unlikely to be a significant reduction in the amount of interleaved spectrum available in the short to medium term. This suggests that action to either encourage or require that Member States make sufficient interleaved spectrum available is not required over this period. Further, encouraging/guaranteeing the availability if interleaved spectrum might impede the potential migration of DTT broadcasters to more spectrally efficient national SFN topologies, in the unlikely event that broadcasters wished to upgrade their networks (perhaps in order to increase the capacity of the DTT platform). Therefore, we do not recommend any action to encourage or require Member States to make sufficient interleaved spectrum available.

In the medium to long term it is possible that either a second sub-band could be adopted or high-power DTT removed from the entire band. In either case, there may no longer be sufficient interleaved spectrum for the two main interleaved uses: SAP/SAP and cognitive technologies. In such circumstances, these uses would be faced with one or possibly two options:

- migrating to other spectrum bands
- using the 470–862MHz band more efficiently (obviously this is not an option if high-power DTT is cleared from the entire band, removing all interleaved spectrum).

Therefore, action may be required either now or in the short to medium term to prepare interleaved spectrum users for this change. For SAB/SAP, this is likely to include migrating to more spectrally efficient digital equipment using the 470–862MHz band, or migrating to other spectrum bands such as the 1452–1559MHz and 1785–1800MHz bands (potentially also using digital equipment). For cognitive technologies the situation is different as it is a potential rather than existing user of the band. If less interleaved spectrum were available, developers of applications using cognitive technologies are likely to automatically consider other bands.

As discussed, the cases for adopting the second sub-band or clearing high-power DTT from the entire band are far from certain, and depend heavily on the evolution of demand for wireless broadband and potential, new services. Given that interleaved users migrating to more efficient technologies or to other spectrum bands will incur costs (e.g. increased development costs, higher unit costs for more spectrally efficient equipment), action now to encourage this migration appears unwarranted. However, we recommend that such actions are reconsidered in the short to medium term, alongside the recommended review of preparatory actions for the adoption of the second sub-band/clearance of the entire band. If at this stage a decision is taken to prepare for the second sub-band/clearance of the entire band, then it may also be beneficial to encourage SAB/SAP users, and possibly cognitive technology uses, to migrate to more spectrally efficient technologies or to other spectrum bands.

Note that sector-specific measures to improve the efficiency of SAB/SAP use of the 470–862MHz, as well as actions to encourage SAB/SAP to migrate to other bands, are considered further in Section 15.2.5 below. Our recommended action for interleaved users is summarised as follows:

Recommended action 3:

No action is currently required to encourage Member States to make sufficient interleaved spectrum available for SAB/SAP and/or other uses. However, any future review of options for further clearance of the band should consider the impact on users of interleaved spectrum (but no *immediate* action on interleaved use is required).

15.2 Sector-specific actions

This section examines what sector-specific actions may be required for our seven categories of potential uses: DTT, broadcast mobile TV, wireless broadband, SAB/SAP, PPDR, cognitive technologies and an innovation reserve. We then discuss what detailed cross-sector action may be required to support possible further clearance of the band.

As described in Section 14.2, sector-specific actions may be required to either support the high-level actions discussed in Section 14.1, or may be warranted in their own right.

15.2.1 DTT

As highlighted in Section 14.1 above, we recommend that Member States be required to adopt the 790–862MHz sub-band by 2015. In the medium to long term, if demand for wireless broadband proves significant and/or new high-value uses emerge, a second sub-band or even the clearance of the whole 470–862MHz band from high-power DTT may be desirable. In all cases, our modelling shows that the adoption of more spectrum efficient technologies/topologies will be necessary. Therefore, action may be desirable to ensure that the adoption of these technologies/ topologies is not delayed. We have identified four areas in which EU-level actions could be warranted:

- creating specifications for DTT receivers
- adopting advanced DTT transmission technologies
- coordinating DTT deployment topologies
- brokering of and multilateral negotiations on DTT replanning.

The creation of specifications for DTT receivers

As stated in Section 14.2.1, DTT stakeholders highlighted the lack of standards/specifications for the performance of DTT receivers, particularly in relation to interference rejection. They also commented during the Stakeholder Hearings (Brussels, 6 March 2009) that including MPEG-4 technology in all sold receivers may be desirable in order to maximise the economies of scale across Europe and to minimise the costs associated with replacing receivers. Obliging all sold receivers to be compatible with DVB-T2 is also an option that was considered. The broadcasting industry also perceived receiver adoption to be a potential barrier to its adopting more efficient technologies as and when required. Therefore, we have identified three options for EU-level action in relation to DTT receivers:

- produce guidelines/require that all sold receivers are MPEG-4 and or DVB-T2 compatible
- produce guidelines/require that all sold receivers meet minimum technology-neutral performance specifications
- specify minimum interference rejection standards for DTT receivers.

In Section 13, we calculated that if the 790–862MHz sub-band is adopted, broadcasters that currently use MPEG-2 would benefit from migrating transmission to a more efficient compression technology, such as MPEG-4, in order to limit the loss in private value of the DTT platform. However, in order for this migration to occur, all MPEG-2 only receivers would need to be replaced by receivers incorporating more efficient technologies (e.g. MPEG-4). At the time of writing, 15 Member States are using MPEG-2 as the only compression technology on their DTT platforms. In most of these Member States, receivers are mainly MPEG-2 compatible only. Encouraging or requiring the inclusion of a more efficient compression technology such as MPEG-4 (specifically H.264/MPEG-4 AVC, the version of MPEG-4 adopted by the DVB Steering Board), in all sold receivers would potentially have two benefits: it could prevent delays to Member States adopting the new compression technology (MPEG-4) for their broadcast transmissions, and it could reduce the total cost of a transition by reducing the number of MPEG-2 only receivers that would need to be replaced. In countries where less efficient broadcast technologies have already been deployed, new receivers incorporating more advanced compression technologies should also be backwards compatible, as this may be required prior to the switchover of all transmissions. In the specific case of MPEG-4, receivers with this functionality are automatically MPEG-2 compatible.

The remainder of this section discusses the advantages and disadvantages of including an advanced compression technology (such as H.264/MPEG-4 AVC) in receivers. Whilst the analysis is not specific to an individual compression technology, for brevity we refer to the compression technology as ‘MPEG-4’.

Below we estimate the value of these two potential benefits.

Preventing delays to Member States adopting MPEG-4 as a transmission technology

The existing base of MPEG-2 receivers represents a significant barrier to the EU-wide adoption of the 790–862MHz sub-band by 2015. Encouraging more MPEG-4 receivers in the market could prevent a delay in the adoption of the sub-band. A one-year delay reduces the value of adopting the sub-band by approximately 10%. This equates to:

- EUR3.6 billion in net present value over 15 years across the EU under a low-demand scenario for wireless broadband

- EUR8.8 billion in net present value over 15 years across the EU under a high-demand scenario for wireless broadband

Note that these figures are equal to the benefits from greater certainty to manufacturers, outlined in Section 13.

The alternative to this upgrade would be a significant loss of programming channels as the spectrum available for high-power DTT is reduced: this could cause a loss of consumer surplus from EUR5.5 billion to EUR11 billion across the EU.

Reducing the number of MPEG-2 only receivers that would need to be replaced in a migration

Requiring that all sold receivers were MPEG-4 compatible would reduce the cost of implementing a migration to MPEG-4 transmission by reducing the number of MPEG-2 only receivers that would need to be replaced. We estimate that if the 15 Member States that currently only use MPEG-2 were to undertake a migration to MPEG-4 in 2015, then cost of replacing all remaining MPEG-2 only would be reduced be around EUR700 million (net present value) if MPEG-4 is required in all sold receivers from 2012.

In order to reach such results we have made the following assumptions:

– DTT penetration of TV sets (including secondary TV sets) would grow from 23% in 2008 to 65% in 2012 in Member States that have not adopted MPEG-4 (we estimate that there is an installed base of MPEG-2 receivers of 36 million in these 15 Member States in 2009).

– DTT receiver average lifetime is 5 years.

– 15% of sold receivers are MPEG-4 compatible in these Member States in 2009, 35% in 2012 and 100% in 2015. In the case where all sold receivers are required to be MPEG-4 compatible from 2012, 100% of sold DTT receivers would be MPEG-4 compliant from 2012 onward.

– The average cost of an MPEG-4 DTT receiver is EUR30 (excluding VAT) in 2015

Using these assumptions, we estimate that the number of MPEG-2 only receivers in these 15 Member States in 2015, as well as the cost to replace them, to be as follows:

	*If receivers **are not** required to by MPEG-4 compatible*	*If receivers **are** required to by MPEG-4 compatible*
Number of MPEG-2 receivers in 2015	40 million	7 million
Cost of replacing receivers	EUR1150 million	EUR220 million
Cost discounted to 2009	EUR880 million	EUR170 million

Figure 15.2: Number of MPEG-2 only receivers in 2015 in 15 MPEG-2 only Member States and the cost of replacing these receivers [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

Note that this benefit could be higher, as this analysis excludes logistical and communications costs that would be involved in order to replace all remaining receivers in the market.

However, there are downsides to requiring MPEG-4 in all receivers. First, it may increase the cost of producing receivers, second, there is a risk that MPEG-4 may not be the optimal choice of technology in the long term, and third, adopting a specific technology may lead to a reduction in innovation in compression technologies. Each of these costs are considered in turn below:

Increasing the cost of producing receivers

We understand from conversations with DTT manufacturers that the average price difference between an MPEG-2 only DTT receiver and an MPEG-4 receiver may currently be around EUR50 excluding VAT (EUR30 for a typical MPEG-2 only receiver compared to EUR80 for a typical MPEG-4 receiver). However, manufacturers expect this difference to reduce significantly in the coming years (at least by half by 2012). Also, it is important to note that this price difference is not purely due to the inclusion of a MPEG-4 decoding chip (especially thanks to technology improvements which allow MPEG-4 decoding chips to be close in size, and hence in price, with an MPEG-2 decoding chip). Typical MPEG-4 receivers have other additional functionality when compared to MPEG-2 only receivers to support HD services, such as including a HDMI interface and better sound quality. We expect that if all receivers were required to be MPEG-4 compatible, manufacturers are likely to also include this additional functionality. This means that any additional cost to produce such receivers would bring service quality benefits to consumers, not only an improvement to the compression technologies.

It is important to recognise that requiring all DTT receivers to be MPEG-4 compatible would have benefits as well as costs.

- *Benefits:* Due to the increased volume in MPEG-4 receiver sales, the unit cost of producing these receivers is likely to fall owing to economies of scale. Therefore, consumers are likely to see a reduction in price. Note that these consumers will not only include consumers in MPEG-4 only Member States but also those in MPEG-2 only Member States that purchase high specification receivers that include MPEG-4 capability.

- *Costs:* Consumers in MPEG-2 only Member States that would have purchased MPEG-2 receivers, will be required to purchase the more expensive MPEG-4 receivers.

In order to estimate these costs and benefits we have made the following assumptions.

By 2015, over 15 million more MPEG-4 only receivers would be sold in the EU if this technology were required in all sold receivers. Our forecast for the number of MPEG-4 receivers sold in both scenarios is shown in Figure 15.3 below:

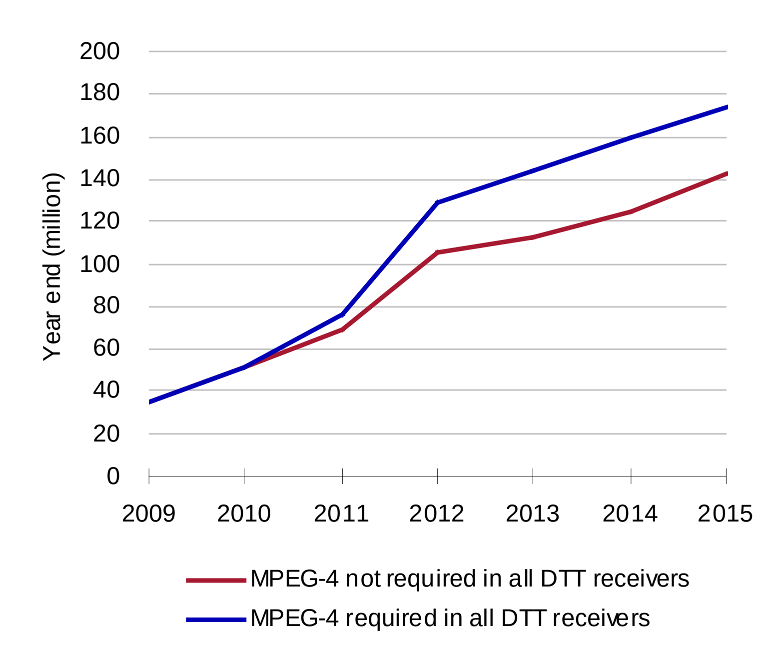

Figure 15.3: Comparison of the evolution of MPEG-4 DTT receivers [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

We assume that the price of MPEG-4 receivers falls more quickly if it is required in all sold receivers. Figure 15.4 shows our forecast prices for MPEG-4 receivers in both scenarios.

EUR (VAT excluded)	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*
MPEG-4 ***not required*** in all receivers	80	70	60	50	40	35	30
MPEG-4 ***required*** in all receivers	80	70	60	45	37	33	30

Figure 15.4: Comparison of the price evolution of MPEG-4 DTT receivers [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

Finally, we assume that MPEG-2 only Member States will upgrade to MPEG-4 in 2015, meaning that by definition all sold receivers all MPEG-4 compatible beyond that date.

The results show that the increase in costs to consumers is largely offset by gains in economies of scale:

- we estimate that consumers would spend EUR470 million[193] more on DTT receivers from 2009 to 2014 if all receivers are required to be MPEG-4 compatible by 2012
- however, we estimate the benefit from more economies of scale to be EUR300 million[194] from 2009 to 2014.

193 Net present value over 6 years.

MPEG-4 may not be the optimal choice of technology in the long term

At first glance this risk appears to be small. 12 Member States have already deployed MPEG-4. It is also a relatively simple upgrade path and most European equipment manufacturers are already producing MPEG-4 compliant equipment. However, there are a number of MPEG-4 variants both available in the market and as well as under development, of which H.264/MPEG-4 AVC is just one. It is possible that this is not the optimal variant.

Adopting a specific technology may lead to a reduction in innovation in compression technologies

If all DTT receivers are required to be MPEG-4 (or more specifically H.264/MPEG-4 AVC) compatible, incentives for manufacturers to develop competing (potentially better) technologies may be removed. This could reduce future innovations in compression technologies.

Overall, although it appears likely that the benefits gained from not delaying the adoption of the 790–862MHz sub-band and/or reducing the cost of migration substantially outweigh the three downsides above, the third option to require that all sold receivers meet minimum technology-neutral performance specifications may be more desirable. We suggest that these minimum specifications should be broadly equivalent to the performance of H.264/MPEG-4 AVC since this is a mature technology that is gaining industry support. Although this approach (as opposed to specifying a particular technology) may reduce the likelihood of generating maximum economies of scale, since it potentially permits more than one technology to be adopted across Europe, it does mitigate the latter two downsides (the risk of choosing a non-optimal technology and stifling innovation). If a preferable technology were to emerge, as long as it met or exceeded the required minimum performance, it would be permitted. Therefore, the added flexibility of this approach appears desirable. Using this approach, no single technology or standard is favoured over others (unlike the case with the Commission’s support of the DVB-H standard for mobile broadcast TV across the EU). Any technologies, MPEG-4 or otherwise, that either meet or exceed the minimum performance standard will be permitted. If the market were to agree on one common technology, this would provide additional economic benefits through maximising the economies of scales and leading to lower equipment prices for consumers.

Defining such technology-neutral minimum specifications may be challenging. There are number of different parameters that would be required to define the performance of a compression technology in a technology-neutral manner. These may include, amongst other parameters, the number of pixels that is transmitted per bit, as well as the motion compression performance (see Section 4.2.1 for further discussion of the components of a compression technology such as

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[194] Net present value over 6 years.

MPEG-4). Therefore, we recommend that research is undertaken to establish firstly whether such a definition is possible, and secondly what the exact technical parameters should be.

As stated in Section 14.1.2, action to adopt a second sub-band is not justified at this stage. As the requirement for the adoption of an advanced digital terrestrial broadcast transmission technology, such as DVB-T2, is closely linked to the further clearance of the band, we suggest revisiting whether action is required regarding the inclusion of a technology with the efficiency improvements similar to DVB-T2 in all sold DTT receivers in the short to medium term (alongside the recommended review of preparatory work for the second sub-band). At that time more will be known about when DVB-T2 is likely to be required. The technology will also be more developed, which will enable a more informed decision to be taken (for instance it will be possible to make judgements based on the use of DVB-T2 in the UK) and would reduce the risk of backing a non-optimal technology or setting an unrealistic minimum performance standard. This review is discussed in more detail in Section 15.2.8 below.

In parallel to requiring that all sold DTT receivers in the EU meet a certain minimum compression performance, we believe it would be beneficial to specify minimum interference rejection standards for DTT receivers, which would ease the introduction of other uses into the band. Specifically, minimum standards should include detailed specifications for the minimum interference tolerance/rejection performance of the receivers, including the rejection of signals received in the adjacent channel and image channel (n+9). Without a common standard, the full use of the 790–862MHz sub-band may be put at risk in some Member States or at least require the introduction of power limits for wireless broadband and hence its efficiency and coverage. Similar to the discussion above regarding the required inclusion of advanced compression technologies (such as MPEG-4), such action may increase the cost of producing receivers. However, we expect that this cost will be largely offset by gains in economies of scale, especially if this action is combined with the inclusion of minimum compression standards. Effectively, manufacturers will only have to adapt these receiver designs and manufacturing processes once to comply with both of these recommendations.

Recommended action 4:

To facilitate an increase in the minimum spectral efficiency from DTT broadcasting, research should be conducted as soon as possible to define the parameters for the required minimum interference rejection standards and the minimum performance of compression technologies for DTT receivers. We suggest that the minimum compression performance is set to reflect the efficiency gains provided by the H.264/MPEG-4 AVC[195] standard.

All sold DTT receivers in the EU should be required as soon as possible to conform to these technology-neutral minimum interference rejection and compression performance standards.

[195] Please note that there are many variants of the MPEG-4 standard. Please see Section 4.2.1 for further details.

Please note that whilst this recommendation makes reference to a specific technology/performance standard, this is a means of facilitating the establishment a realistic/achievable minimum efficiency standard, since such a technology-neutral specification does not currently exist. The reference to a specific technology (H.264/MPEG-4 AVC) does not preclude an alternative technology being adopted (for example by an individual Member State), particularly in cases where such an alternative technology offers even greater efficiency gains.

The adoption of advanced DTT transmission technologies

As stated in Section 14.2.1, without any EU action, Member States may introduce new DTT transmission techniques, such as MPEG-4 and DVB-T2 over widely differing timeframes. In order to drive coordinated adoption of new transmission technologies, two options have been identified previously:

- produce guidelines/require that Member States adopt MPEG-4 and/or DVB-T2
- produce guidelines/require that all DTT transmission meet technology-neutral performance specifications.

One major barrier to adopting advanced DTT transmission technologies is the installed base of MPEG-2/DVB-T only DTT receivers. Such a barrier for migration to an advanced compression technology, such as MPEG-4, may be reduced by requiring all sold DTT receivers to meet minimum compression performance specifications as discussed above.

As mentioned in Section 14.2.1, requiring Member States to adopt an advanced compression technology, such as MPEG-4, in the short term would provide a high level of certainty for industry (in particular to equipment manufacturers). It may also decrease the risk of delaying the adoption of the 790–862MHz sub-band. As highlighted above, such a delay could decrease the total value generated from adopting this sub-band by approximately 10% (between EUR4.4 billion and EUR10.7 billion across the EU depending on the demand scenario).

Requiring Member States to adopt an advanced broadcast transmission technology such as DVB-T2 in the medium to long term would also accelerate the possibility of adopting a second sub-band across Europe, bringing greater certainty that the benefits would be realised. As outlined, a delay in the adopting a second sub-band by one year could reduce the total value generated by between EUR1.7 billion and EUR 3.1 billion depending on the demand scenario.

However, obliging all Member States to adopt a common timeframe for the adoption of advanced technologies, such as MPEG-4 and DVB-T2 may be detrimental to suppliers and consumers in some Member States, as they may be obliged to replace their existing equipment either sooner than would otherwise have been the case, or even unnecessarily. Indeed the adoption of an advanced broadcast transmission technology such as DVB-T2 may not be required if a second sub-band is not adopted. In our modelling in Section 13, we estimate the cost of upgrading all DTT networks to DVB-T2 to be around EUR10 billion, i.e. more than twice the cost of upgrading all DTT networks to MPEG-4 (around EUR4 billion). Further, as per our discussion regarding DTT receiver specifications, adopting specific technologies carries the risk of choosing a non-optimal technology and may stifle innovation.

As 12 Member States have already adopted MPEG-4 for their DTT platform, and other Member States are migrating from MPEG-2 to MPEG-4 in the near future, we believe that producing non-obligatory guidelines on minimum compression performance specifications (equivalent to MPEG-4), in addition to requiring all sold receivers to also meet these specifications, would allow sufficient momentum across the EU leading to an accelerated adoption of more efficient compression technologies such as MPEG-4, thus securing the majority of the benefits outlined above. A non-obligatory target of 2015 for the adoption of these standards would coincide with our recommendation above that all Member States are required to adopt the sub-band by 2015.

In the medium term, producing non-obligatory guidelines on the timeline for either adopting a specific broadcast transmission technology, such as DVB-T2, or setting a minimum bit rate performance for DTT transmissions may also be required if it is anticipated that spectrum demand for other uses than DTT will be high and hence the clearance of a second sub-band may also be beneficial for Europe. This review is discussed further in Section 15.2.8 below.

Recommended action 5:

Non-obligatory guidelines should be produced regarding the timeline for the adoption of minimum compression performance specifications for DTT transmission by Member States. As with our recommended action 4, we suggest that these should be equivalent to H.264/MPEG-4 AVC. This action will support the clearance of the 790–862MHz sub-band by 2015.

Member States should be requested to share their plans to migrate to more advanced transmission technologies so as to assist other Member States in developing their own plans.

Please note that regarding receiver performance standards, the reference to a specific technology in the recommendation above does not preclude alternative technologies from being adopted, particularly if they provide further improvements in spectral efficiency.

DTT deployment topologies

As stated in Section 14.2.1, Member States vary in their plans for the adoption of national SFNs. Currently, only a few Member States have implemented such a topology for some of their national multiplexes and SFNs are mainly deployed at regional level. However, significant efficiency gains could be realised through greater use of national SFNs. In Section 14.2.1, we identified two options for EU-level action to promote the coordinated use of national SFNs:

- produce guidelines on the timeline for wider adoption/deployment of national SFNs
- require that Member States more widely adopt national SFNs including specific timelines.

As mentioned in Section 11.1, our economic modelling suggests that upgrading some or all DTT networks to national SFNs is likely to be required in order to maximise value if a second sub-band is adopted. In our economic modelling, we estimated such cost to be around EUR14 billion. However, given the uncertainty over the case for the second sub-band, we do not know yet whether further investment in national SFNs is a necessary or cost-effective action.

We therefore suggest that no definitive action should be taken in the short term regarding DTT deployment topologies. We suggest that this is reviewed in the short to medium term, similar to the above discussion on the adoption of advanced broadcast technologies for transmission, such as DVB-2. By this time SFNs will be more developed, with potentially more Member States having implemented it on a national basis, which will allow a more informed decision to be taken. This review is discussed further in Section 15.2.8 below.

Brokering bilateral and multilateral negotiations on DTT replanning

In Section 14.2.1, we highlighted potential concerns about the ability of Member States on a bilateral or multilateral basis to achieve timely consensus on the replanning of DTT necessary to facilitate the coordinated releases of dividend spectrum for new uses. (This is both in the short-term for the 790–862MHz sub-band or potentially in the medium to long term for a second sub-band). In particular, negotiations may be complicated by asymmetries between Member States' positions, resulting from uneven GE-06 assignments. Without such coordination, there is a risk that some Member States may find themselves very adversely (and arguably unfairly) affected by any high-level actions aimed at clearing spectrum. These concerns suggest the Commission or other European bodies could play a more active role in promoting and brokering negotiations between Member States, as well as with non-EU countries.

Regarding the 790–862MHz sub-band, there is evidence that bilateral and multilateral negotiations are having considerable success. For example, we understand that a number of Member States in north-west Europe have already been working closely together to coordinate the relocation of their DTT allocations from the sub-band to lower frequencies. Therefore, the requirement for and benefit from EU-level brokering may be limited. A possible exception to this is in relation to countries bordering the EU to the east, such as Russia and Turkey, where further coordination is required with several Member States to facilitate the timely realisation of the sub-band.

Any decision to plan for or introduce a second sub-band would require much more complex coordination amongst Member States than is necessary for the first sub-band. Almost certainly, an international conference similar in scale to GE-06 would be required. It would seem sensible for the Commission to have a role in those negotiations and in ensuing discussions, given that European coordination would be a key rationale for any clearance of a second sub-band. We note that such major international conferences have significant lead times, potentially of several years. Therefore, even ahead of any decision to commence preparatory work for the adoption of a second sub-band, it may be beneficial for research to commence on the objectives, requirements and logistics of such a conference.

Any decision on the location of a second sub-band will no doubt affect Member States in different ways, meaning that Member States may begin negotiations from unequal positions. As such, the Commission could help broker negotiations, ensuring that they result in all Member States receiving a 'fair share' of revised DTT assignments. The primary responsibility for negotiations would still lie with the Member States' SMA.

We have not attempted to quantify the benefits of the Commission taking on a more active role in brokering negotiations between Member States on DTT assignments. We believe the main benefit would be to reduce the risk of spectrum releases being delayed. A delay of one year has been estimated above for the 790–862MHz sub-band (between EUR4.4 billion and EUR10.7 billion across the EU) as well as a second sub-band (between EUR1.7 billion and EUR 3.1 billion).

Recommended action 6:

The Commission should make itself available as a neutral broker in negotiations between Member States, or between Member States and neighbouring non-EU countries regarding the re-allocation of spectrum in the 470–862MHz band.

15.2.2 Broadcast mobile TV

As explained in Section 14.2.2, the main benefit of European coordination of spectrum availability for broadcast mobile TV would be to ensure optimal economies of scale in networks and receivers. We identified just one potential action regarding broadcast mobile TV:

- producing guidelines on the range of frequencies that could be made available for broadcast mobile TV.

Benefits from economies of scales may be significant for broadcast mobile TV. For comparison, we have estimated in our analysis for Section 13 that economies of scale for wireless broadband would be EUR1.7 billion in present value. The situation for mobile TV receivers using the DVB-H standard, however, is quite different from mobile broadband, in that they are able to tune over a wide range. Indeed the tuning range of the DVB-H-enabled Nokia N96 is 470–750MHz, i.e. the entire part of the band below 750MHz (above which interference would be experienced with cellular systems using the 900MHz band). Therefore, economies of scale benefits would be limited to the cost saving realised by reducing this tuning range, rather than on the whole equipment cost, and so presumably would be significantly less than the number calculated for wireless broadband for terminals (this does not affect the network equipment).

If a smaller range was proposed for DVB-H, it would be beneficial to choose frequencies at the lower end of the band, avoiding a potential second sub-band. If a second sub-band was adopted, DVB-H networks would need to be relocated further down the band.

However, there may be downsides to creating a smaller tuning range. A number of Member States have either deployed or are planning to deploy DVB-H networks using their existing GE-06 assignments. These assignments are likely to be spread across the band, including frequencies outside of any proposed smaller tuning range. Either these networks would need to adapt to using frequencies within the smaller tuning range, or these Member State would not benefit from the increased economies of scale that it would generate. Also, given that equipment already in the market tunes across large parts of the band, it is not clear that there would be a significant benefit from narrowing this range.

We believe that producing guidelines at this stage for a smaller tuning range seems premature and therefore we do not believe that European level action is warranted.

15.2.3 Commercial wireless broadband

In Section 14.2.3 we identified a concern about the inflexibility of spectrum requirements associated with wireless broadband technologies, in particular the FDD technologies that are currently the leading candidate technology for offering wireless broadband using digital dividend spectrum. In certain respects, FDD technologies are spectrally efficient; by separating the uplink and downlink, and it is possible to use adjacent spectrum without significant frequency separation. However, the requirement for FDD systems to operate with the same fixed duplex spacing in all Member States, in order to realise common economies of scale, means that the systems are very inflexible regarding location relative to other uses. This inflexibility creates an unduly strong dependence on regulatory intervention and European coordination, inhibits expansion of services using FDD systems and acts as a barrier to entry for competing technologies. This inflexibility is particularly problematic in a large band such as 470–862MHz, where there is scope to share spectrum across many different uses. This is because FDD requirements for specific band plans effectively limit the scope for realising benefits from spectrum liberalisation initiatives, such as WAPECS.

In the future, if it were possible to redesign FDD systems so that they were more flexible in their use of spectrum, then this might allow (a) Member States to vary the amount of spectrum allocated to wireless broadband without compromising European scale economies; and (b) the expansion or contraction of wireless broadband spectrum during the course of a licence term in response to changing demand without the need to adopt further sub-bands. In turn, this may reduce the need for the coordination of spectrum availability at the European level. Alternatively, the same benefits may be achieved if cellular systems changed from FDD to TDD technology, especially if frequency separation requirements between TDD users could be reduced. Note, however, that such changes would primarily improve the scope for flexibility in the deployment of different types of medium-power services across Europe. Cross-border interference concerns may still limit the scope to deploy wireless broadband and DTT at the same frequencies in adjacent Member States.

In the Section 14.2.3, we identified two potential actions to improve the flexibility in wireless broadband deployment in the 470–862MHz band:

- encouraging research into frequency agile wireless broadband systems, such as FDD systems that could operate with a variable duplex
- prioritising access to spectrum for flexible systems.

Neither of these actions are practical steps in relation to the adoption of the 790–862MHz sub-band. The timescale for this sub-band to be implemented would not allow for the development of more flexible FDD systems for wireless broadband. Therefore, we see no alternative but to continue with the adoption of this sub-band, with all Member States making spectrum available in a way that is likely to facilitate a common European band plan.

However, these actions may be practical for future potential releases of dividend spectrum, either in the context of a second sub-band or clearance of high-power DTT from the band. If greater flexibility can be introduced without unduly increasing technology costs, then the economic benefits of more efficient spectrum use could be substantial, especially for Member States whose optimal requirements differ significantly from the European average.

The following example illustrates the potential benefits from having flexible technologies that could share a 92MHz sub-band (the same size as a potential second sub-band of 698–790MHz). The values given are plausible but hypothetical. The range for total incremental value created from the sub-band of between EUR95 billion and EUR110 billion is consistent with our combined demand Scenario E and supply Scenario 2 in Section 13, where a second sub-band is adopted, and there is high demand for both DTT and wireless broadband.

Suppose two different potential services emerged as frontrunners for deployment in a second sub-band, one using FDD to offer a wireless broadband service and the other using a TDD technology to supply an alternative service. In principle, the 92MHz sub-band in each Member State could either be split between these services, e.g. 62MHz for FDD and 30MHz for TDD, or allocated exclusively to FDD. Also suppose that the optimal course of action varies across Member States, such that one group of Member States favours FDD only and a second group prefers a mixed approach. A plausible set of values for each group of Member States is illustrated in Figure 15.5 below.

	Value created by releasing xMHz for wireless broadband FDD		*Value created by releasing xMHz for other TDD use*	
	62MHz	92MHz	0MHz	30MHz
First group of Member States	EUR40 billion	EUR70 billion	-	EUR15 billion
Second group of Member States	EUR25 billion	EUR30 billion	-	EUR15 billion

Figure 15.5: Illustrative example of value created by allocating spectrum in a second sub-band to new uses [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

There are three possible approaches that Europe could take:

- All Member States could allocate the spectrum entirely to FDD. The total value created would be EUR100 billion, with the first group gaining EUR70 billion and the second group gaining EUR30 billion.

- All Member States could allocate 62MHz to FDD and 30MHz to TDD. The total value created is EUR95 billion, with the first group gaining EUR55 billion and the second group gaining EUR40 billion.

- Each Member State could chose their preferred deployment. The first group could allocate 92MHz to FDD, while the second group could split the spectrum between FDD and TDD. The total value created would be EUR110 billion, with the first group gaining EUR70 billion and the second group gaining EUR40 billion.

It would therefore be preferable to allow Member States to chose their own approach, as the economic value to the EU would be EUR10 billion higher than the next best approach of exclusive FDD allocation. However, such an approach would only be possible with compatible technologies.

Suppose instead that the FDD system could only be deployed with a fixed duplex split, so all Member States have to adopt the same approach or face losing all their benefits from FDD. In this case, all Member States would have to carry out one of the first two approaches. For the EU as a whole, the best approach would be exclusive FDD use, but this would be a very undesirable option for the second group of Member States, as they would forego benefits of EUR10 billion, about one-third of the total value, by not allocating any spectrum to TDD.

In summary, we believe that moving to more flexible technologies could generate significant value for the EU as a whole. The benefits to individual Member States whose domestic demand conditions differ significantly from the European average may be very large, because those Member States may no longer be obliged to follow their neighbours in order to realise common benefits from economies of scale.

It is difficult to judge how effective recommended actions would be in achieving such benefits. Further research into more frequency agile wireless broadband systems is needed for such technologies to become commercially viable. This research needs to be carried out by manufacturers, but European and national bodies could influence its direction. Prioritising access to future coordinated releases of dividend spectrum for flexible systems would be a very effective way to incentivising manufacturers to undertake research. The Commission could announce that it is actively considering options to prioritise flexible systems for any future coordinated releases of digital dividend spectrum. However, such decisive action could be counter-productive if cost effective systems do not materialise.

Recommended action 7:

The Commission or other appropriate European bodies should work together with Member States to encourage research into the development of more frequency-agile technologies for wireless broadband (e.g. FDD systems with variable duplex).

15.2.4 Wireless broadband for public protection and disaster relief (PPDR)

As mentioned in Section 4.1, CEPT has recently initiated work to consider future spectrum requirements for PPDR. The focus of this work is to consider options in bands in the 300MHz–1GHz range, potentially on a shared basis with defence around the current PPDR allocations (380–400MHz) or as part of the digital dividend in the 470–862MHz band. We have identified two options for EU-level action that might be considered if a clear need for a PPDR wireless broadband network using digital dividend spectrum is established:

- produce guidelines on, or require Member States to use part of the 790–862MHz sub-band for a PPDR system
- produce guidelines on, or require Member States to use an alternative sub-band for PPDR in the 470–790MHz band.

As part of the recent CEPT Working Group Frequency Management (WGFM) meeting[196], several Member States mentioned that they do not currently see a need for additional spectrum for PPDR services. As a result, the need for a Europe-wide wireless broadband network for PPDR using digital dividend spectrum remains very uncertain.

Given this uncertainty, it does not seem necessary to reserve spectrum in the 790–862MHz sub-band for PPDR. This sub-band will be made available soon (2012 in some Member States and 2015 across the EU at the latest if our recommendations in Section 15.1.1 are implemented). The opportunity cost of reserving 2×16MHz[197] of spectrum in the sub-band is also very high. From existing studies and our analysis in Section 13, this opportunity cost is between EUR13 billion and EUR32 billion.

Allocating spectrum for PPDR below 790MHz may be more appropriate than allocating part of the 790–862MHz sub-band, especially as a second sub-band may be adopted in the medium term (as discussed in Section 14.1.2). The medium term appears more appropriate, given that there does not appear to be definite short-term demand for spectrum for PPDR. The opportunity cost of allocating

196 This meeting took place on 18–22 May 2009 in Montenegro.

197 2*16MHz is what the European Telecommunications Standards Institute proposed to be given from the digital dividend to emergency services.

some spectrum to PPDR below 790MHz is lower than in the 790–862MHz sub-band, but is still unlikely to be small. Based on existing studies and our analysis from Section 13, this opportunity cost may range from EUR1 billion to EUR3 billion.

There also appear to be other, lower opportunity cost options for providing such a service for PPDR users. As highlighted by the satellite industry during the Stakeholders’ Hearings, satellite providers will soon supply services to PPDR users in the 2GHz band (the S-Band). Additionally, a range of initiatives is ongoing to identify the possibilities to use some spectrum in the 300–400MHz band. The CEPT WGFM proposed that the ECC begin talks with the military to study the possible use of military bands in the 300–400MHz range. One benefit from using this range would be the synergies derived from using spectrum near to the existing PPDR networks in the 380–400MHz sub-band. Further, the opportunity cost of the 300–400MHz range is likely to be significantly lower than in the 470–862MHz band. Such opportunity costs have been estimated by Ofcom in order to set administered incentive pricing (AIP) for spectrum in the UK. Ofcom set prices for the 470–862MHz band at GBP500 000 per MHz per year,[198] while prices levied on the Ministry of Defence for the 230–400MHz band are much lower at GBP198 000 per MHz per year.[199]

Overall given the high opportunity costs of reserving spectrum in either the 790–862MHz sub-band or another sub-band below 790MHz, the low certainty of demand for spectrum for PPDR in many Member States, and the other potential, lower opportunity cost options in other spectrum bands (300–400MHz and 2GHz), we do not recommend any action at this stage to enable the allocation of spectrum in the 470–862MHz band for PPDR.

Should a specific case for digital dividend spectrum to be set aside across the EU, this could be considered as part of the review of the economic case for further band clearance under recommended action 2.

15.2.5 SAB/SAP

In Section 14.2.5 we highlighted that economies of scale in SAP/SAP equipment production may not be being realised fully across the EU, and the reorganisation of dedicated channels in some Member States may be an opportunity to gain such benefits. We also highlighted that SAB/SAP may not have access to sufficient spectrum if the spectrum beyond the 790–862MHz sub-band was cleared for new use. We also identified five potential actions for SAB/SAP:

- request that Member States share plans regarding the relocation of dedicated frequency channels for SAB/SAP

198 Indepen and Aegis for the Ofcom (October 2005), “Study into the potential application of Administered Incentive Pricing to spectrum used for Terrestrial TV & Radio Broadcasting”.

199 PA Consulting Group for the British Ministry of Defence (November 2008), “Defence Demand for Spectrum: 2008 – 2027”.

- producing guidelines on a common set of frequency channels to be dedicated for SAB/SAP use
- requiring that Member States make a dedicated channel available for SAB/SAP
- encouraging the migration of SAB/SAP to alternative frequency bands
- supporting the development of digital technology for SAB/SAP.

The main benefit from either producing guidelines for common frequencies for dedicated national channels for SAB/SAP, or indeed requiring Member States make such channels available, is economies of scale. Such action would focus the vast majority of SAP/SAB equipment in the 470–862MHz band into a small number of spectrum channels, critically within the tuning range of the majority of equipment. It is difficult to estimate the economies of scale that would be derived from common frequencies for dedicated national channels for SAB/SAP. The analysis below provides both a low estimate (assuming a 10% reduction in unit costs if all Member States adopt such dedicated channels) and a high estimate (assuming a 20% reduction in unit costs if all Member States adopt such dedicated channels).

We estimate that there will be about 1.4 million pieces of SAB/SAP equipment used in the 470–862MHz band in the EU in 2010 (1.35 million wireless microphones, 50 000 IEMs and 11 000 talkback systems). This has been calculated by scaling up forecasts of equipment in the UK by Analysys Mason.[200] We assume that 95% of this equipment would be used in dedicated channels if they were available. This is the figure assumed by Analysys Mason based on the actual amount of equipment that tunes over Channel 69 in the UK. We also assume that the average lifetime of SAP/SAP equipment is 10 years, and therefore each year, 10% of equipment is replaced. Finally we assume that the average unit cost in a dedicated channel, but without any benefit from EU-wide economies of scale, to be EUR310 for a wireless microphone, EUR555 for an IEM and EUR1665 for a talkback system.

As mentioned above, if dedicated channels were available throughout the EU, we have assumed a 10% reduction in unit costs in our low estimate and 20% in our high estimate. If only a small number of Member States adopted common, dedicated channels we assume that these reductions would also be smaller:

- 9% reduction in unit costs in our low estimate and 18% in our high estimate if the dedicated channels are available in 15 Member States (assuming an average population for EU Member States)
- 8% reduction in unit costs in our low estimate and 15% in our high estimate if the dedicated channels are available in 6 Member States.

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200 Analysys Mason (May 2008), "Opportunity cost and AIP calculations for spectrum proposed for award to a band manager with obligations to PMSE for the Ofcom".

Note that we assume a diminishing benefit from economies of scale with each incremental Member State.

Figure 15.6 provides the results[201] of our analysis. The scale of the benefits is modest, when compared to the benefits from some of the other proposed actions.

	Number of Member States making available common frequencies for dedicated national channels for SAB/SAP		
	6	*15*	*27*
Economies of scale - Low estimate	EUR14 million	EUR40 million	EUR53 million
Economies of scale - High estimate	EUR27 million	EUR81 million	EUR106 million

Figure 15.6: Discounted economies of scale derived from common frequencies for dedicated national channels for SAB/SAP [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

The choice of a common frequency range for dedicated SAP/SAB channels could in theory be anywhere in the 470–790MHz range (i.e. avoiding the uplink and downlink ranges of the 790–862MHz sub-band), although it may be sensible to choose frequencies away from potential options for a second sub-band. Currently there appear to be two main options (although others could and should be considered).

- *The FDD duplex split in the 790–862MHz sub-band*: If the sub-band is adopted and used for FDD, a possible option is the centre gap between uplink and downlink (possibly 821–832MHz). The opportunity cost of this spectrum appears low, as in order to avoid interference to wireless broadband use in the sub-band, the duplex gap will be limited to low-power use. However, the SAB/SAP community are concerned about this option, due to possible interference from wireless broadband devices, and because the nearest interleaved spectrum to this centre gap is further than the tuning range of most equipment. This means that equipment could not be purchased that operates over both the centre gap and interleaved spectrum below 790MHz.

- *Channels surrounding Channel 38 (606–614MHz)*: the UK is considering dedicating Channel 38 to SAB/SAP. This channel is currently used for radio astronomy in the Netherlands, preventing medium- or high-power use in large areas of adjacent Member States. Therefore, this may be a viable option for a dedicated SAP/SAP channel in other Member States. Although, there may be interference issues regarding its use for SAB/SAP in the Netherlands itself, as well as other neighbouring Member States. Also these frequencies may also be used for DTT in Member States that are a significant distance from the Netherlands (depending on the use of this channel for radio astronomy in Member States other than the Netherlands).

201 Net present value over 15 years.

As outlined above, there may be modest economies of scale benefits from ensuring that all Member States make a dedicated channel available nationwide. However, given that many Member States do not currently have dedicated channels for SAB/SAP, it is not clear that there is a case for making such channels available in all Member States, even once the economies of scale benefits are included. Further, with the possible exception of the FDD duplex split in the 790–862MHz sub-band, the opportunity cost of making these channel available may be high. This is because DTT may need to be removed from such channels. Therefore, action that requires all Member States to make a dedicate channel available appears unwarranted.

Although providing guidelines on the frequency range for locating a dedicated channel appears to have few downsides, the benefits are small. Further, the choice of the location of dedicated channels for SAB/SAP needs to consider a number of national factors. For example, Channel 38 is the chosen option in the UK due to radio astronomy use in the Netherlands preventing high-power transmission in that channel in the UK. However, Channel 38 may not be a viable option in other Member States. Therefore, is appears more pragmatic to request that Member States considering relocating dedicated channels share their plans. By doing this Member States may be able to coordinate to a common range(s), thus increasing economies of scale.

In Section 15.1.3 we considered the option of encouraging interleaved users, including SAP/SAP users, to either migrate to more efficient technologies (likely to be digital technologies in the case of SAB/SAP) or migrate to other spectrum bands (probably the 1452–1559MHz and 1785–1800MHz bands). We concluded that such action was not warranted either now or in the short to medium term, as sufficient interleaved spectrum is likely to be available over this period. However, if in the medium to long term either the second sub-band is adopted or the entire band is cleared of high-power DTT, then SAB/SAP will not have sufficient interleaved spectrum to meet demand. Therefore, action should be reconsidered in the short to medium term, alongside the recommended review of preparatory actions for the adoption of the second sub-band/clearance of the entire band. This review is discussed further in Section 15.2.8 below.

Our recommended action for SAB/SAP can be summarised as follows:

Recommended action 8:

We propose that Member States considering relocating dedicated nationally available frequency channels for SAB/SAP (as part of their plans to clear the 790–862MHz sub-band) are requested to share their plans.

15.2.6 Cognitive technologies

In Section 14.2.6 we explained that the principal source of a European dimension regarding cognitive technologies is economies of scale. Certain applications, such as wireless local area networks, may be potential mass-market products that depend on economies of scale. Some applications may also benefit from international roaming. We also identified two possible actions regarding cognitive technologies:

- developing common guidelines on regulatory measures for cognitive technologies
- producing guidelines or requiring that Member States adopt a common frequency range(s) for cognitive technologies.

Common guidelines regarding the technical and regulatory standards for cognitive technologies would have two main benefits:

- Firstly, it is likely, although not guaranteed, that if Member States choose to allow cognitive technologies they would follow these standards. This would maximise economies of scale. Note that it is very difficult to estimate the size of the benefits from economies of scale, as cognitive technologies and their applications are in their infancy.
- Secondly, it would also provide confidence to manufacturers to develop applications using cognitive technologies in the 470–862MHz band, potentially accelerating the time to market. In Section 9.2, we estimate that if cognitive technologies take off, the value to the EU of the use of cognitive technologies in the 470–862MHz band to be EUR20–30 billion.[202] If the introduction of these technologies were delayed by one year this value would reduce by between EUR0.9 billion and EUR1.3 billion.

There appears to be little downside to the EU developing a view on these technical and regulatory parameters as the cost of doing so is relatively small and it does not *require* Member States to allow cognitive technologies; such a decision would remain at the national level. If a Member State has concerns regarding these technologies, particularly the potential interference to existing services in the band, they can choose not to permit them. The downside of this action would be a slight reduction in economies of scale.

When considering these technical and regulatory parameters, it may be advantageous to use those adopted by the FCC in the USA as a starting point. In November 2008, the FCC decided that cognitive technologies using interleaved spectrum may be required to use both spectrum detection and geolocation. Should these parameters adopted by the FCC be deemed to be appropriate for the EU, economies of scale would be increased further. Moreover, this approach would mean that if some Member States choose not to allow cognitive technologies, other Member States are not unduly impacted as they would still benefit from significant economies of scale. However, at the second Member States' workshop on 26 June 2009, one Member State noted that the parameters recommended by the FCC may not be suitable for Europe.

It would also be beneficial if Member States adopted common frequency ranges for devices that use cognitive technologies. This would provide certainty to equipment manufacturers over the

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202 Net present value over 15 years.

tuning range their equipment should support, thus potentially accelerating the time to market. Although obligatory action would maximise this benefit, given that such technologies are in their infancy it would be difficult now to know what the optimal frequency range would be. Given the risk of choosing a non-optimal range, we believe that such obligatory action is not warranted. However, considering the frequency range of devices, developing common guidelines for the technical and regulatory conditions for cognitive technologies appears to have little downside.

We understand that European SMAs are contributing to WRC-11 agenda item 1.19 regarding regulatory measures for cognitive technologies via CEPT (CPG project team A). It may be appropriate for such common guidelines to feed into developing a Common European Position. In light of this work, we recommend the following actions for cognitive technologies.

Recommended action 9:

Common guidelines should be developed regarding the technical parameters (including frequency ranges) and regulatory conditions for the introduction of cognitive technologies in the 470–862MHz band. These may feed into the EU's contribution to WRC-11 agenda item 1.19.

Member States are not required to either adopt this position nor permit cognitive technologies, these decisions remain at the national level.

15.2.7 Innovation reserve

In Section 14.2.7, we discussed the possibility of EU-level action to identify part of the digital dividend spectrum as an "innovation reserve". This reserve could be used as a shared resource for experiments involving radio spectrum, or as an allocation option in the future.

In the short term, identifying such an innovation reserve across the EU would have a large opportunity cost. It would need to either encroach into the 790–862MHz sub-band or into the remaining DTT spectrum. The former would have a large cost (based on existing studies, the impact of reducing the 790–862MHz sub-band by 20MHz could be between EUR7.3 billion and EUR17.7 billion). The latter would result in the loss of an additional multiplex in most Member States, which would cause a significant loss of valuable TV programming channels (which translates into a loss of consumer surplus of between EUR4.6 billion and EUR9.2 billion), unless the networks are further upgraded to DVB-T2 (which would cost in the region of EUR13 billion).

As mentioned in Section 14.2.7,, the benefits gained by enabling experimental uses to operate over part of the digital dividend spectrum would still be achievable with current arrangements, for instance by making available interleaved spectrum. There are no obvious benefits to coordinating this at EU level: experimental deployments are highly unlikely to benefit from any economies of scale or roaming, irrespective of whether the spectrum used is harmonised across the EU.

We therefore recommend no EU-level action regarding this specific use.

15.2.8 Action to support possible further clearance of the band

As discussed above, there are number of potential sector-specific actions that, although not warranted now, may be warranted if either a second sub-band is adopted or the entire band is cleared. These are actions to:

- encourage the compatibility of DTT receivers with advanced broadcast transmission technologies (such as DVB-T2)
- encourage the adoption of advanced broadcast transmission technologies (such as DVB-T2)
- encourage the adoption of national SFNs
- prepare for a GE-06 style conference to renegotiate DTT assignments if a second sub-band is adopted
- encourage SAB/SAP users to either migrate to more spectrally efficient digital equipment or to migrate to spectrum outside the 470–862MHz band.

We recommend that the suggested review of preparatory actions for the adoption of the second sub-band/clearance of the entire band also considers the above potential actions.

Recommended action 10:

The review of preparatory actions for further band clearance (recommended action 2) should consider a number of supporting sector-specific actions, including:

- encouraging DTT receivers to be compatible with advanced broadcast transmission technologies (such as DVB-T2) or to meet minimum bit rate specifications
- encouraging the adoption of advanced broadcast transmission technologies (such as DVB-T2) transmission or adoption of minimum bit rate specifications for transmission technologies
- encouraging the adoption of national SFNs
- preparing for a GE-06 style conference to renegotiate DTT assignments
- encouraging SAB/SAP users to either migrate to more spectrally efficient digital equipment or to migrate to spectrum outside the 470–862MHz band.

Part D: Implementation roadmap and conclusions

16 Implementation roadmap

In Section 15 we developed as series of high-level and sector-specific recommended EU-level actions regarding the digital dividend. In this section we provide an roadmap for how these actions may be implemented between now and 2020. The central part of this implementation roadmap is a proposed timeline for activities that will need to be undertaken. However, we also highlight the dependencies between these activities, as well as key milestones and decision points for the implementation.

In this section we first outline the proposed timeline for the implementation, before describing each of the activities in detail. We then outline the main risks associated with the implementation roadmap and highlight any possible mitigating steps. Finally we outline further technical work that we recommend takes place as part of the implementation roadmap.

16.1 Proposed implementation timeline

Figure 16.1 and Figure 16.2 below provide our proposed timeline for the implementation of the high-level and sector-specific recommended actions. In the timeline for high-level recommended actions, we have not only shown those activities that are definitely recommend to occur, we also show broad actions that may occur in the future subject to future reviews (e.g. activities regarding the possible clearance and award of the second sub-band).

There is uncertainty regarding the exact timing for all of the proposed activities, milestones and decision points. Therefore, these timelines should be viewed as approximate, especially for those activities, milestones and decision points that are planned for the medium to long term. For those key milestones where there is significant uncertainty (e.g. possible clearance and award of the second sub-band) we have illustrated a range of potential timings.

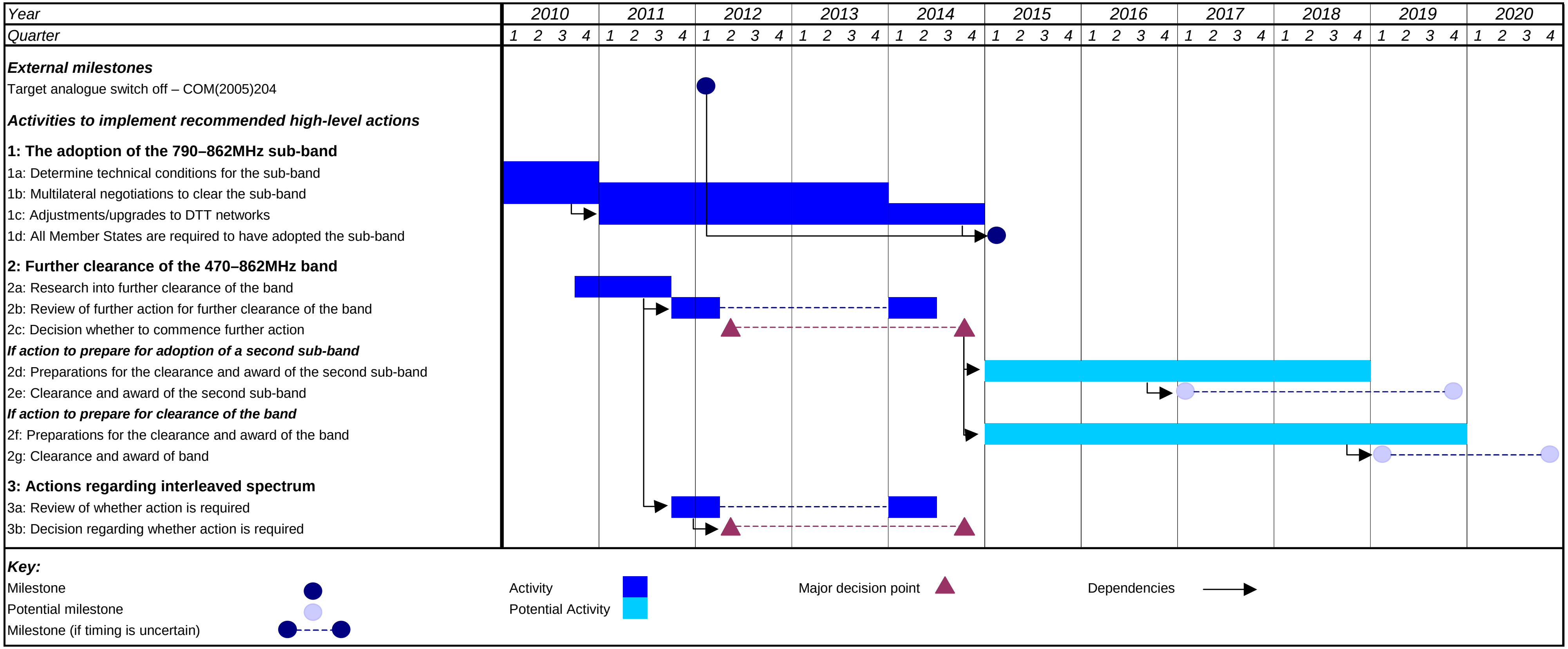

Figure 16.1: Implementation timeline for the recommended high-level actions [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

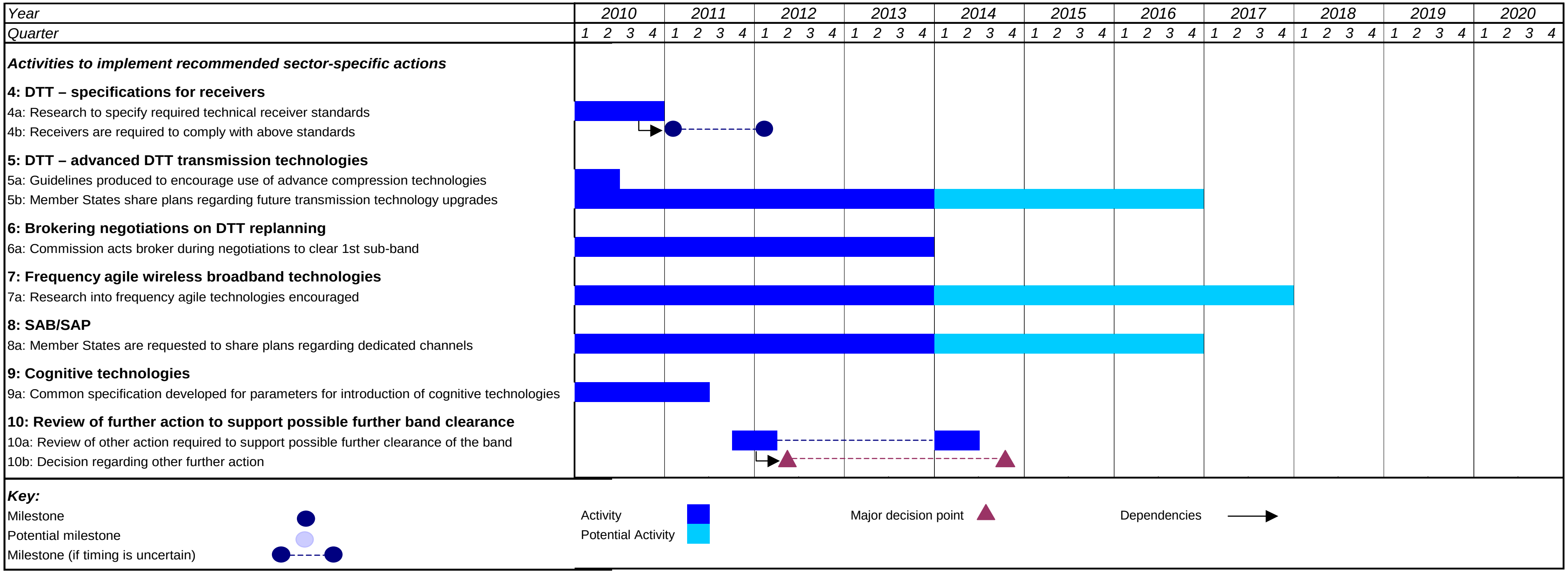

Figure 16.2: Implementation timeline for the recommended sector-specific actions [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

16.2 Description of the activities

In this section we describe each of the proposed activities, milestones and decision points in turn. In each case we give the proposed years in which each may be carried out, as well as other activities, milestones and decision points on which they are dependent.

16.2.1 High-level recommended actions

Recommended action 1: The adoption of the 790–862MHz sub-band

Activity, milestones and decision points	Description	*Proposed timing*	*Other activities on which it is dependent*
1a: Determine technical conditions for the sub-band	Technical research is undertaken, potentially by CEPT, to establish the exact permissible emissions at border areas. These limits should permit at borders medium uses such as wireless broadband but not high-power uses such as high-power DTT.	2010	
1b: Multilateral negotiations to clear sub-band	Bilateral or multilateral negotiations will need to take place between neighbouring Member States, as well as with non-EU countries, to replan DTT in order to clear the 790–862MHz sub-band. Note that specific EU action to support these negotiations is discussed in activity 7a below.	2010–2013	
1c: Adjustments/ upgrades to DTT networks	Following the renegotiation of DTT assignments, Member States will need to adjust their DTT networks to operate on the agreed frequencies. Member States may also chose to upgrade their DTT networks to more efficient transmission technologies (e.g. MPEG-4) in order to prevent loss of TV programming channels on the platform.	2011–2014	1b
1d: All Member States are required to have adopted the sub-band	All Member States will be required to have awarded the 790–862MHz sub-band in a format that enables it to be used for wireless broadband by 1 January 2015. At this stage the technical restrictions outlined in activity 1a are put into place.	1 January 2015	1c. Analogue switch-off occurring in a timely manner

Figure 16.3: Recommended action 1: proposed activities [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

Recommended action 2: Further clearance of the band

Activity, milestones and decision points	*Description*	*Proposed timing*	*Other activities on which it is dependent*
2a: Research into further clearance of the band	In the short-to-medium term we suggest that limited research is conducted regarding either the adoption of a second sub-band or the clearance of high-power DTT from the entire band. This should include: • size, frequency location and band plan for a second sub-band • the costs and feasibility of the necessary upgrades to other TV platforms to maintain universal free-to-view TV services This analysis will be a major input into activity 2b.	1 year prior to 2b: Review of further clearance	
2b: Review of further action for further clearance of the band	In the short to medium term we recommend that a review is undertaken regarding whether to continue with preparatory action to either adopt a second sub-band or clear the entire band.	Circa 2011–2013	2a, and not before decisions regarding the 790–862MHz sub-band have largely been resolved
2c: Decision whether to commence further action	Following the review, we anticipate a decision regarding further action is made in the short to medium term. Note that this review need not provide a "go or no go" decision regarding either of these actions. Rather this review may, if demand for wireless broadband and/or other new uses is sufficient, recommend further preparatory action for these two options. Final "go or no go" decisions make come at a later date.	Circa 2012–2013	2b
2d: Preparations for the clearance and award of the second sub-band	If a decision is made to pursue further action to adopt a second sub-band, then such preparations would be required. These may include further renegotiations of GE-06 assignments and adjusting/upgrading DTT networks.	Circa 2015–2018	2c
2e: Clearance and award of the second sub-band	If the clearance of a second sub-band is deemed to be desirable we envisage a implementation date in the medium to long term (2017–2019).	Circa 2017–2019	2d

2f: Preparations for the clearance and award of the band	If a decision is made to pursue further action to clear the entire band, then such preparations would be required. These may include upgrading other TV platforms to offer a universal free-to-view service, and replacing consumer aerials and set-top boxes..	Circa 2014–2019	2c
2g: Clearance and award of band	If the clearance of the entire band is deemed to be desirable we envisage a implementation date in the long term (2019 and beyond).	Circa 2019–2020 and potentially beyond	2f

Figure 16.4: Recommended action 2: proposed activities [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

Recommended action 3: Actions regarding interleaved spectrum

Activity, milestones and decision points	*Description*	*Proposed timing*	*Other activities on which it is dependent*
3a: Review of whether action is required	At the same time the case for preparatory action to either adopt a second sub-band or clear the entire band is reviewed, we suggest that the case for action to encourage interleaved users (and particularly SAB/SAP users) to either migrate to more spectrally efficient equipment or migrate to another band is also reviewed. If action is deemed necessary to prepare for either the adoption of a second sub-band or clearance of the band, this would significant reduce the availability of interleaved spectrum.	Circa 2011–2013	2a
3b: Decision regarding whether action is required	The above review should determine both whether action is required to encourage interleaved spectrum users to migrate to either more spectrally efficient equipment or another spectrum band, as well as exactly the nature of this action.	Circa 2012–2013	3a

Figure 16.5: Recommended action 3: proposed activities [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

16.2.2 Sector-specific recommended actions

Recommended action 4: DTT – specifications for receivers

Activity, milestones and decision points	*Description*	*Proposed timing*	*Other activities on which it is dependent*
4a: Research to specify required receiver standards	This research should define the technical parameters for the required minimum performance of compression technologies and the minimum interference rejection standards for DTT receivers. It is difficult to determine at this stage the exact dimensions of the minimum compression performance specification. It is likely to involve as number of aspects such as the number of pixels that is transmitted per bit as well as the motion compression performance. The required performance may be chosen to reflect the efficient gains provided by the H.264/MPEG-4 AVC standard. The minimum interference rejection standards should specify the level of emissions that receiver should tolerate outside of the wanted channel.	2010	
4b: Receivers are required to comply with above standards	In our recommended actions we state that all sold DTT receivers should comply with the above compression and interference rejection standards as soon as possible. If at all possible this requirement should be in place by Q1 2012, if not before.	2011–Q12012	4a

Figure 16.6: Recommended action 4: proposed activities [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

Recommended action 5: DTT – advanced DTT transmission technologies

Activity, milestones and decision points	*Description*	*Proposed timing*	*Other activities on which it is dependent*
5a: Guidelines produced to encourage use of advance compression technologies	Guidelines are developed as soon as possible that encourage Member States to use compression for DTT transmission equal or better to the parameters defined in activity 4a. These guidelines should include a target date for the completion of such a migration by January 2015.	First half 2010	
5b: Member States share plans regarding future transmission technology upgrades	The Commission should create a mechanism by which Member States can share their plans for future upgrades to transmission technologies (e.g. MPEG-4, DVB-T2). Member States are then requested to share these plans.	2010 onwards	

Figure 16.7: Recommended action 5: proposed activities [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

Recommended action 6: Brokering negotiations on DTT replanning

Activity, milestones and decision points	*Description*	*Proposed timing*	*Other activities on which it is dependent*
6a: Commission acts broker during negotiations to clear 1st sub-band	We anticipate that multilateral negotiations to clear the 790–862MHz sub-band will take place between circa 2010 and 2013. The Commission should be available as a neutral broker during this period for negotiations both between Member States and between Member States and non-EU countries.	2010–2013	

Figure 16.8: Recommended action 6: proposed activities [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

Recommended action 7: Frequency agile wireless broadband technologies

Activity, milestones and decision points	*Description*	*Proposed timing*	*Other activities on which it is dependent*
7a: Research into frequency agile technologies encouraged	In this activity the Commission or other European bodies should encourage and direct research into frequency agile technologies (e.g. FDD systems with variable duplex). However, we suggest that the actual research itself is best carried out by equipment manufacturers.	2010 onwards	

Figure 16.9: Recommended action 7: proposed activities [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

Recommended action 8: SAB/SAP

Activity, milestones and decision points	*Description*	*Proposed timing*	*Other activities on which it is dependent*
8a: Member States are requested to share plans regarding dedicated channels	The Commission should create a mechanism by which Member States that are relocating dedicated channels for SAB/SAP can share their plans. Member States are then requested to share these plans.	2010 onwards	

Figure 16.10: Recommended action 8: proposed activities [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

Recommended action 9: Cognitive technologies

Activity, milestones and decision points	*Description*	*Proposed timing*	*Other activities on which it is dependent*
9a: Common specification developed for parameters for introduction of cognitive technologies	In collaboration with Member States, the Commission or another appropriate European body develops guidelines regarding the technical parameters (including frequency ranges) and regulatory conditions for the introduction of cognitive technologies in the 470–862MHz band. These may feed into the development of a European Common Position for the EU’s contribution to WRC-11 agenda item 1.19.	2010–11	

Figure 16.11: Recommended action 9: proposed activities [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

Recommended action 10: Review of further action to support possible further band clearance

Activity, milestones and decision points	*Description*	*Proposed timing*	*Other activities on which it is dependent*
10a: Review of other action required to support possible further clearance of the band	The recommended review of preparatory actions for the adoption of the second sub-band/clearance of the entire band should also consider related sector-specific actions: • encouraging DTT receivers to be compatible with advanced broadcast transmission technologies (such as DVB-T2) • encouraging the adoption of advanced broadcast transmission technologies (such as DVB-T2) • encourage the adoption of national SFNs • prepare for a GE-06 style conference • encourage SAB/SAP to migrate to more spectrally efficient digital equipment or to spectrum outside the 470–862MHz band	Circa 2011–2013	2a
10b: Decision regarding other further action	If the review favours preparatory action for the adoption of the second sub-band/clearance of the entire band, then appropriate sector-specific actions should also be taken.	Circa 2012–2013	10a

Figure 16.12: Recommended action 10: proposed activities [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

16.3 Key risks and mitigating steps

During the development of the implementation roadmap, we have identified a number of key risks, these are:

- analogue switch-off is not complete in some Member States by 2012, thus delaying the adoption of the 790–862MHz sub-band
- multilateral negotiations to clear the 790–862MHz sub-band take longer then expected, thus delaying the adoption of the sub-band
- preparatory action for the potential adoption of the second sub-band/clearance of the band does not occur quickly enough to meet the proposed timescales
- it is not possible to produce technology-neutral minimum compression performance specifications.

In this section we discuss each risk in turn to examine how likely each one is; the scale of impact should it occur; and what mitigating steps could be taken (if any) to ensure that the recommended actions can be implemented within the proposed timescales.

16.3.1 Analogue switch-off is not completed by 2012 in some Member States

Likelihood of risk and potential impact

We understand that the GE-06 plan ends protection of any analogue TV transmissions as of June 2015. Therefore, while there is no strict legally binding deadline, it would be difficult to continue analogue transmissions after that date. We recommend that the 790–862MHz sub-band should be adopted by all Member States by 2015. However, there is a risk that Member States may not be able to complete ASO by this time. If this is the case it will clearly be impossible to clear and award the sub-band. However, the risk of this eventuality appears relatively small. Five Member States have already completed ASO (Germany, Finland, Luxembourg, the Netherlands and Sweden) and 19 Member States are planning ASO in 2012, it appears unlikely that these plans will slip by three years. Poland is planning ASO in 2015, but could achieve this sooner depending on market conditions. Only Romania and Ireland are still developing their DSO plans but intend completing ASO by 2012.

If Member States’ ASO’s did slip beyond 2015, this would not only prevent the adoption of the sub-band in those Member States, but the continued high-power analogue transmissions in the 790–862MHz sub-band would also restrict the ability of neighbouring Member States to use the sub-band for uses other than high-power DTT.

A potentially greater risk is neighbouring non-EU countries not completing ASO by 2015. We expect that this is unlikely in key non-EU countries such as Switzerland and Norway, however, it is more probable in countries that adjoin the EU's eastern border (e.g. Russia, Turkey). If these neighbouring non-EU countries do not achieve ASO by 2015, it would restrict neighbouring Member States use of the sub-band by uses other than high-power DTT.

Potential mitigation steps

In order to mitigate the small risk that Member States may not complete ASO by 2015, the Commission may consider asking Member States to make firm commitments to completing ASO by 2015.

The Commission's ability to prevent neighbouring non-EU countries from not completing ASO by 2015 is limited. Requiring all EU Member States to adopt the sub-band by 2015 will incentivise non-EU countries to also adopt the sub-band, due to the potential economies of scale. In order to do this they will need to have completed ASO. Therefore, the Commission could help present the case of completing ASO on time and adopting the sub-band to such non-EU countries.

16.3.2 Multilateral negotiations to clear the 790–862MHz sub-band take longer then expected

Likelihood of risk and potential impact

Given the asymmetric nature of GE-06 assignments across Member States, some Member States will rely on these negotiations more than others. Even so, there are incentives for Member States, both with and without large numbers of GE-06 assignments in the sub-band, to complete such negotiations successfully and in a timely fashion. Member States with few assignments in the sub-band will be restricted in their use of the sub-band if other Member States do not clear high-power DTT from the sub-band. Even so, these negotiations are complicated and are likely to be lengthy; delays in these negotiations would delay the adoption of the sub-band.

Member States near EU borders will also need to negotiate with non-EU countries. Given that these Member States are not required to adopt the sub-band by 2015, delays may occur.

Potential mitigation steps

As outlined in recommended action 6, the Commission should make itself available as a neutral broker for negotiations between Member States. It may also consider fostering best practice for these negotiations across the EU. Finally, if it becomes apparent that the negotiations are not progressing as hoped, the Commission may consider either setting a target completion date for the negotiations between Member States, or requiring that these negotiations are complete by a certain date.

The Commission should also assist in negotiations between Member States and non-EU countries. It could also help present the case of adopting the sub-band to non-EU countries.

16.3.3 Preparatory action for the potential adoption of the second sub-band/clearance of the band does not occur quickly enough

Likelihood of risk and potential impact

The scale of such preparatory actions is large (e.g. implementing an alternative free-to-view universal TV service) and the timescale for implementation is likely to be long. In the short to medium term, Member States are likely to be focused on the implementation of the 790–862MHz sub-band, potentially at the expense of preparatory actions for further clearance of the band. Therefore, there is a risk of delay.

If such preparatory action does not occur quickly enough, either in a few Member States or across all Member States, this could delay the adoption of the second sub-band/clearance of the band (if either are deemed desirable).

Potential mitigation steps

As outlined in recommended action 2, we suggest that some research takes place ahead of a review to assess whether to commence preparatory actions. This should minimise the risk of delay. However, we suggest that the implementation of the 790–862MHz sub-band should take priority over actions to prepare for further clearance of the band. Therefore, if delays are caused by not wanting to jeopardise the adoption of the first sub-band, we suggest that the risk of these delays is accepted.

16.3.4 It is not possible to produce technology-neutral minimum compression performance specifications

Likelihood of risk and potential impact

As discussed in Section 15.2.1 defining truly technology-neutral specifications for compression performance is likely to be complex. Indeed, there is a risk that it may not be possible. This would mean that our recommended actions are not possible to require all sold receivers to comply with these specifications, as well as to produce guidelines for all DTT networks to also meet these specifications.

Potential mitigation steps

If activity 4a (research to specify required technical receiver standards) concludes that it is not possible to define such specifications in a technology-neutral manner, we recommend that our recommended actions are changed to:

- all sold DTT receivers are required to be H.264/MPEG-4 AVC compatible by 2012
- non-obligatory guidelines are produced regarding the adoption of H.264/MPEG-4 AVC transmission by Member States by 2015.

These recommended actions are clearly not technology neutral, and therefore have the downsides associated with technology specific actions: the risk that the chosen technology is non-optimal in the long term and the stifling of innovation. However, as explained in Section 15.2.1, the case for such action is warranted, over no action, given the scale of the benefits.

16.4 Recommendation for additional technical work

The activities recommend as part of the implementation roadmap as outlined in Section 16.2 above, includes a number of pieces of technical work.

Technical work	*Timing*
1a: Determine technical conditions for the sub-band	2010
2a: Research into further clearance of the band	1 year prior to activity 2b: Review of further clearance of the band
4a: Research to specify required technical receiver standards (minimum compression performance and interference rejection)	2010
7a: Research into frequency-agile technologies encouraged	2010 onwards
9a: Common specification developed for parameters for introduction of cognitive technologies	2010–11

Figure 16.13: Recommended additional technical work [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]

Note that in order to be concise we have not repeated the details of these activities: these are given in Section 16.2.

In addition, we recommend that further work is undertaken, potentially by CEPT, to assess how widespread the issue of interference to cable networks may be in individual Member States and the costs of resolving any harmful interference problems.

17 Conclusions and summary of recommendations

In this report we have demonstrated that there is a strong European dimension to current and future policy on use of the digital dividend. This is based on:

- EU policy goals, including: horizontal policies that promote the internal market, and foster competition, innovation and inclusion; the Electronic Communications Regulatory Framework governing spectrum management; the i2010 agenda for creating a knowledge-based economy and bridging the broadband gap; and the European Recovery Plan

- coordination of cross-border interference, whereby high-power use such as DTT in one Member State could prevent the same frequencies being used in another

- economies of scale in equipment manufacture and international roaming/interoperability, aided by a common frequency allocation and common adoption of standards.

Therefore, decisions made by individual Member State necessarily have an impact on other Member States.

We have also conducted economic analysis to understand the most beneficial broad use of the 470–862MHz band across the EU. Based on the results of this analysis we identified a series of options for high-level and sector-specific actions that could be undertaken at the EU level. We then conducted further quantitative and qualitative economic analysis to evaluate these options for action, before then recommending a series of actions. Our recommendations are designed to support the long-term, efficient use of the digital dividend spectrum and maximise the value created for the EU as a whole.

In summary, our most important recommended actions are as follows:

- all Member States should be required to clear and award the 790–862MHz sub-band by 2015 in a format that enables it to be used for wireless broadband

- there should be a future review, to be scheduled in the short to medium term, to consider preparatory actions for potentially undertaking further clearance of the 470–862MHz band. However, a decision to commit to further clearance may not be taken until a later date, particularly since this is likely to require a political decision by Member States.

- the scope for these high-level recommendations to realise substantial and timely benefits across Member States could be reinforced by EU action on a number of sector-specific issues. Most notably, we recommend that all sold DTT receivers in the EU should be required as soon as possible to conform to minimum interference rejection and compression performance standards.

A summary of all our recommended actions is provided in Figure 17.1 below:

	Recommended action
High-level options	
Actions supporting the adoption of a 790–862MHz sub-band	All Member States are required to clear and award the 790–862MHz sub-band by 2015 in a format that enables it to be used for wireless broadband. Member States are encouraged to award the sub-band on a service- and technology-neutral basis, in accordance with the Commission’s WAPECS principle. To support these actions, technical restrictions should be in place to prevent emissions at borders exceeding medium-power thresholds. Member States are free to design their own award processes, but these should not preclude the possibility of spectrum being used for wireless broadband using paired spectrum channels in line with the CEPT FDD band plan Where possible, Member States are encouraged to adopt the sub-band prior to 2015.
Actions to clear further spectrum below 790MHz	There is insufficient information about future demand for wireless broadband and other services to currently make a decision on whether Member States should be encouraged to clear spectrum in addition to the sub-band at 790–862MHz. However, the possibility of action in the medium-long term to either adopt a second sub-band or to clear entirely the 470–862MHz band should not be ruled out. We propose that the issue of further band clearance is reviewed again in short to medium term. This review should only take place once decisions regarding the first sub-band are largely resolved. The review should consider what subsequent preparations would be required to facilitate the rapid and coordinated implementation of further spectrum clearance across Member States if an EU decision was made to proceed with the second sub-band or total clearance. Some limited research into the two options for further clearance should be initiated ahead of this review, so as to reduce any future delay in implementation.
Actions concerning services currently offered in interleaved spectrum	No action is currently required to encourage Member States to make sufficient interleaved spectrum available for SAB/SAP and/or other uses. However, any future review of options for further clearance of the band should consider the impact on users of interleaved spectrum (but no immediate action on interleaved use is required)
Sector-specific actions	
DTT	To facilitate an increase in the minimum spectral efficiency from DTT broadcasting, research should be conducted as soon as possible to define the parameters for the required minimum interference rejection standards and the minimum performance of compression technologies for DTT receivers. All sold DTT receivers in the EU are required as soon as possible to conform to these technology-neutral minimum interference rejection and compression performance (set to reflect the efficiency gains provided by the H.264/MPEG-4 AVC) standards. Non-obligatory guidelines are produced regarding the timeline for the adoption of minimum compression performance specifications for DTT transmission by Member States by 2015. Member States are requested to share plans to migrate to more advanced transmission technologies (such as MPEG-4 and DVB-T2).

	The Commission should make itself available as an neutral broker in negotiations between Member States, or between Member States and neighbouring non-EU countries regarding the re-allocation of spectrum in the 470–862MHz band.
Wireless broadband	The Commission or other appropriate European bodies should work together with Member States to encourage research into the development of more frequency-agile technologies (e.g. duplex variable FDD technologies) for wireless broadband.
SAB/SAP	We propose that Member States considering relocating dedicated nationally available frequency channels for SAB/SAP (as part of their plans to clear the 790–862MHz sub-band) are requested to share their plans.
Cognitive technologies	Common guidelines are developed regarding the technical parameters (including frequency ranges) and regulatory conditions for the introduction of cognitive technologies in the 470–862MHz band. These may feed into the EU's contribution to WRC-11 agenda item 1.19.
Detailed action across sectors	The recommended review of preparatory actions for the adoption of the second sub-band/clearance of the entire band also considers knock on sector-specific actions: • encouraging DTT receivers to be compatible with advanced broadcast transmission technologies (such as DVB-T2) or to meet minimum bit rate specifications • encouraging the adoption of advanced broadcast transmission technologies (such as DVB-T2) or adoption of minimum bit rate specifications for transmission technologies • encouraging the adoption of national SFNs • preparing for a GE-06 style conference to renegotiate DTT assignments • encouraging SAB/SAP users to either migrate to more spectrally efficient digital equipment or to migrate to spectrum outside the 470–862MHz band.

Figure 17.1: Summary of recommended actions [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]