**Report for the European Commission**

# 'Exploiting the digital dividend' – a European approach

Final report – executive summary

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# Contents

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# 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 document 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.

*Please note that any section references (e.g. Section 3) refer to sections of the main report.*

## 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.

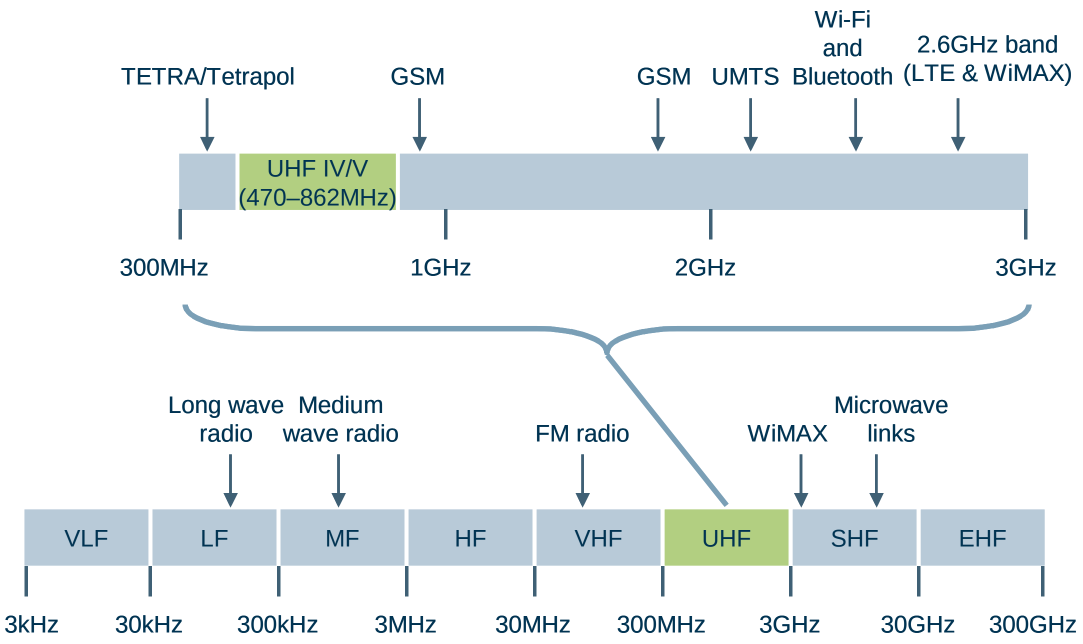


*Figure 1.1: The radio spectrum with current (and future) major uses highlighted [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]*

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.

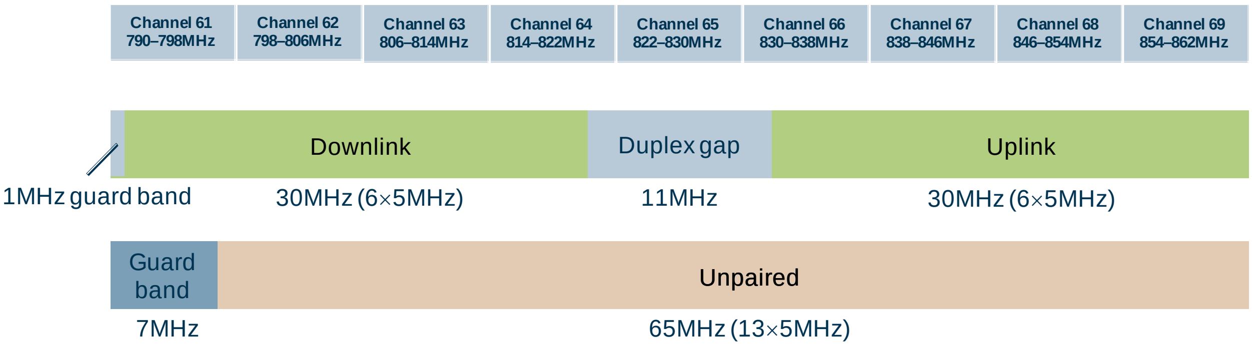


*Figure 1.3: Draft harmonised channel arrangements for the 790–862MHz sub-band [Source: ECC PT1]*

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<br>Germany<br>Luxembourg<br>Netherlands<br>Sweden | Denmark<br>Greece | Austria<br>Estonia<br>Malta<br>Spain | Belgium<br>Cyprus<br>France<br>Hungary<br>Latvia | Bulgaria<br>Czech Republic<br>Italy<br>Lithuania<br>Portugal<br>Romania<br>Slovakia<br>Slovenia<br>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.

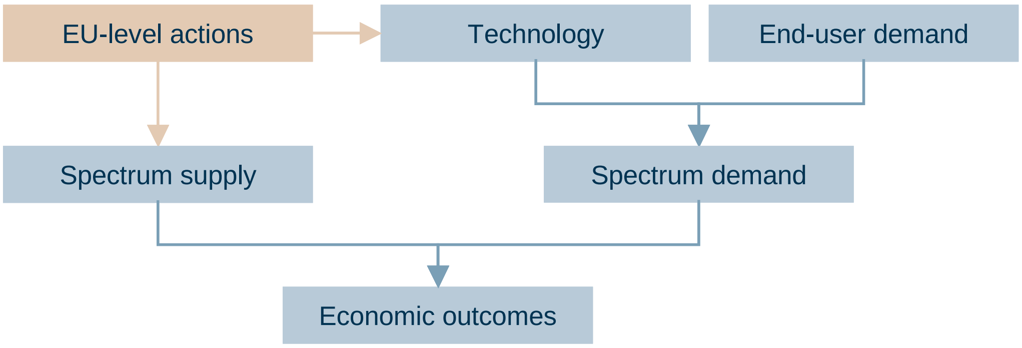


*Figure 1.7: How the economic value generated by the 470–862MHz band will be determined [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]*

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.

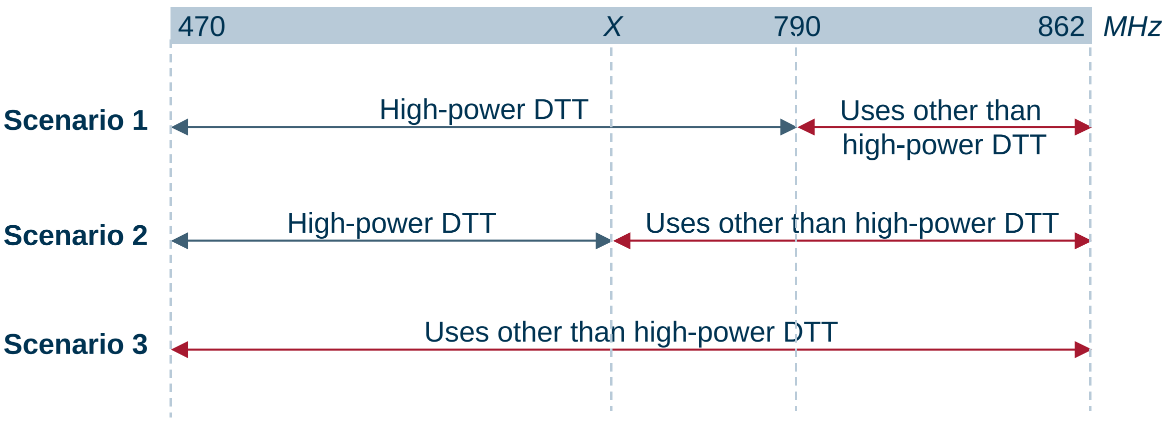


*Figure 1.8: Broad supply scenarios for the 470–862MHz band [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]*

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.

| | | Wireless broadband | | |
|---|---|---|---|---|
| | | Low | High | High with new use |
| DTT | 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.

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.

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.

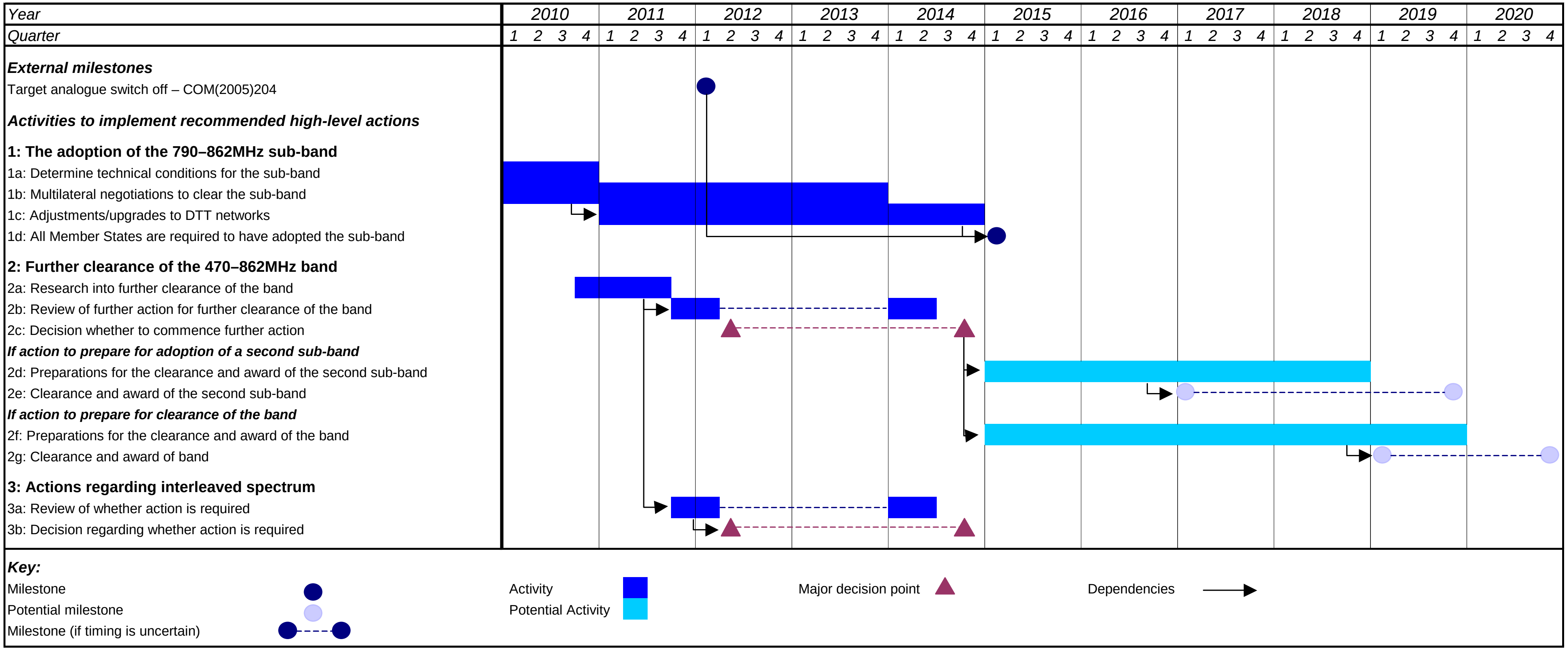


*Figure 1.12: Implementation timeline for the recommended high-level actions [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]*

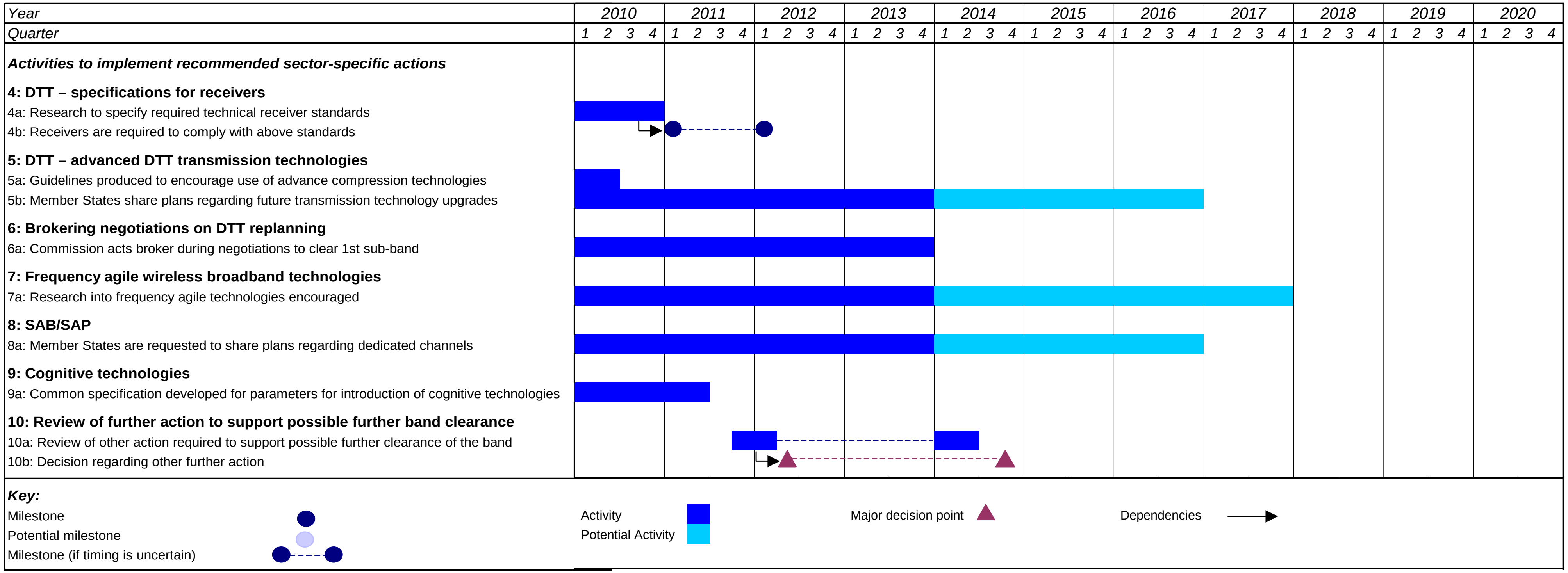


*Figure 1.13: Implementation timeline for the recommended sector-specific actions [Source: Analysys Mason, DotEcon and Hogan & Hartson, 2009]*