Review of Digital Dividend Options in Greece

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0 Executive Summary

0.1 Introduction

The term "digital dividend" refers to the reduction in the amount of radio spectrum required to deliver terrestrial TV services when the transmission technology is migrated from analogue to digital Over the last five years interest has grown in the use of the digital dividend to support wider roll-out of other services such as mobile broadband communications. Work is advancing in Europe to harmonise part of the digital dividend to ensure a Europe-wide market and hence minimise the cost for delivering such services. The proposed harmonised spectrum is in the range 790 – 862 MHz. In some countries it may be possible to release additional spectrum, on a non-harmonised basis, which could be used for other services such as additional fixed or mobile TV, public safety communications or programme making and special events (PMSE) applications.

This report reviews the current situation regarding digital switchover and the prospect for releasing and utilising a digital dividend in Greece and other European countries.

0.2 International activities relating to the digital dividend

There have been a number of recent developments both within the International Telecommunications Union (ITU) and at European level that have attempted to maximise the potential benefits from the digital dividend. The 2007 ITU World Radio Conference (WRC-07) decided to allocate 790 – 862 MHz to the mobile service on a co-primary basis with broadcasting throughout Europe and Africa by 2015 at the latest. In Europe, CEPT is developing detailed plans to facilitate the introduction of mobile services in this spectrum, on a harmonised but non-mandatory basis. The scope of the CEPT work covers technical conditions for mobile services, channelling arrangements and cross-border co-ordination issues.

The proposed channel plan for frequency division duplex (FDD) operation in the harmonised European digital dividend is shown below:

Figure 0.1 FDD channelling arrangement: 5 MHz block size / 30 MHz paired

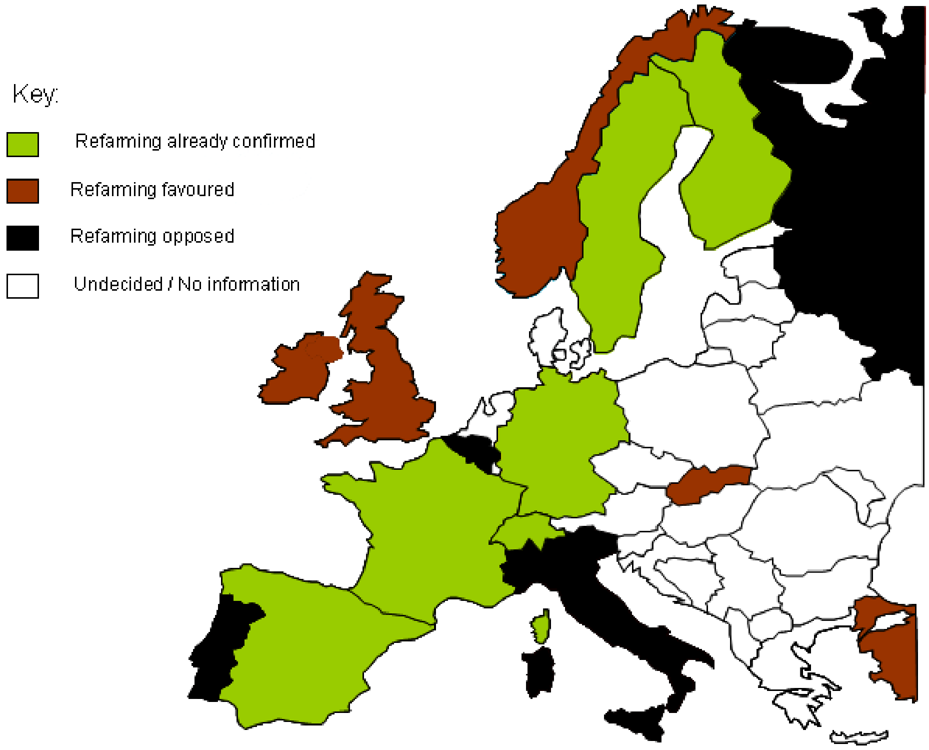
791-796	796-801	801-806	806-811	811-816	816-821	821 - 832	832-837	837-842	842-847	847-852	852-857	857-862
Downlink						Duplex gap	Uplink					
30 MHz (6 blocks of 5 MHz)						11 MHz	30 MHz (6 blocks of 5 MHz)					

Although an alternative time division duplex (TDD) plan exists this approach is unlikely to be suitable for large cell, wide area networks due to the difficulties of synchronising transmit and receive signals over wide areas. For cross-border coordination interference limits have been defined for mobile terminals, mobile base stations and domestic television receivers.

0.3 Status of the digital dividend in individual EU countries

Although there appears to be growing support for the adoption of a harmonised European digital dividend band, this is not universal. Some countries, such as Italy and Belgium, have particular problems due to their extensive existing or planned use of channels 61 – 69 for digital television. The diagram below shows which countries have already decided to implement the harmonised band, those that are supportive of the proposal and those that are against.

Figure 0.2 Position of EU and neighbouring countries on release of spectrum for mobile applications in the 790 - 862 MHz band



A number of EU countries (13 of the 27 Member States) currently have military systems operating in this band[1]. However, only three of these (Belgium, France and Germany) have specifically requested protection for these services under the GE-06 plan and our understanding is that in none of these administrations will the presence of military services constrain the national rollout of digital TV or other commercial services using these frequencies.

Another significant user of the UHF TV band is PMSE, which deploys wireless microphones and temporary radio links in the band, often using frequencies that are

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[1] source: EFIS

not being used by TV stations locally. PMSE may have less opportunity to share frequencies with TV stations following digital switchover.

The freeing up of additional frequencies beyond the harmonised band could be attractive for services such as PMSE or fixed broadband access, which are less dependent on mass market economies of scale and international roaming than mobile services and hence less dependent on harmonised frequencies. So far only one country (the UK) has explicitly committed to release additional spectrum for other services beyond the proposed harmonised band, although Ireland has recently made a similar proposal and we would expect other countries to consider similar initiatives once their digital switchover plans are finalised.

The ITU Geneva 2006 (GE-06) frequency plan forms the basis for digital TV planning in Europe. Under the plan most countries have been allocated sufficient spectrum to provide the equivalent of 7 or 8 national digital multiplexes. In addition, some countries plan additional multiplexes to provide regional or part-national coverage. There is no common approach to licensing digital TV services in Europe, however in most cases it appears that the operator of the multiplex is independent of the broadcasters providing the content. An occasional exception to this is in the case of larger public service broadcasters, who may be assigned their own multiplex(es) to carry their own programme channels.

Unlike other sectors of the electronic communications market, many DTT licences are technology specific, to provide retailers and consumers with certainty regarding the compatibility of digital receivers with local transmission networks. This may become less necessary over time as new generations of set-top boxes and integrated digital receivers acquire more flexibility. Frequencies are in general assigned to the multiplex operator or the operator of the transmission network, rather than to the broadcasters directly. Broadcasters typically receive licences that entitle them to capacity on a multiplex. This differs from the situation in Greece, where frequencies are assigned directly to broadcasters who are then required to co-operate in setting up a multiplex operator.

0.4 Developments outside Europe

The potential value of the digital dividend is illustrated by the outcome of the recent auction of similar spectrum in the USA, which yielded almost $20 Billion in bids, mostly from established mobile operators. The availability of new spectrum below 1 GHz is particularly attractive both in terms of the coverage advantages relative to higher frequency bands and the substantial bandwidth available, which almost doubles the availability of cellular mobile spectrum below 1 GHz.

0.5 Impact of releasing digital dividend spectrum in Greece

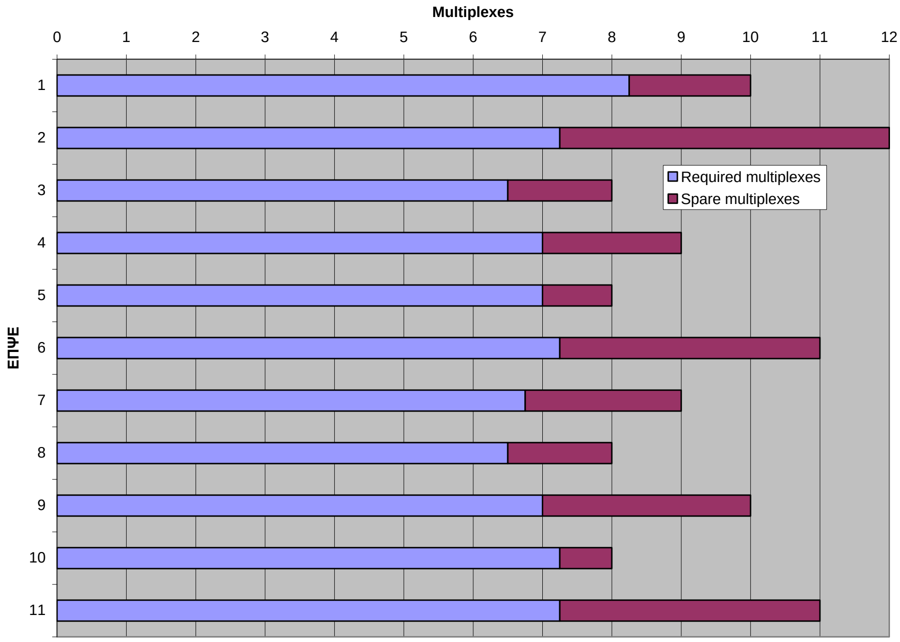
The Greek television market comprises national, regional and local stations. There are four national stations operated by the public service broadcaster ERT and there will be eight national private digital stations. Regional and local stations are all private and the number varies by region, with up to eleven officially licensed stations in some areas. There are also two national pay-TV stations. All of the analogue national and regional stations will be entitled to capacity on the digital networks once the switchover is complete. There may also be a requirement to accommodate local stations but this is not yet clear.

As a minimum, the post-switchover digital plan must support existing national and regional stations, as defined in relevant legislation. ERT will operate a further two multiplexes, one of which will be shared with the two existing pay-TV stations, and a separate multiplex will also be licensed for mobile TV. There will therefore be a requirement for six national multiplexes, assuming that up to four existing analogue stations can be accommodated per multiplex. The number of multiplexes to support regional stations will vary by region, depending on the number of existing analogue stations.

The post-switchover frequency plan is defined in a document prepared by the National Technical University of Athens and provides for between 8 and 12 frequencies in each of 23 defined single frequency networks (SFNs) serving 11 broader coverage areas ("ΕΠΨΕs"). Our analysis of the frequency assignments made to local and regional stations under Greek legislation[2] indicates that in all but one of the ΕΠΨΕs there will be no more than five regional stations, which would require an additional two multiplexes (eight multiplexes in total). Our analysis shows that all of the SFNs in the digital plan would still have sufficient frequencies to deliver the required national and regional multiplexes even if the entire 790 – 862 MHz band were to be removed. The remaining spare capacity in each ΕΠΨΕ is shown in the figure below:

[2] Decision 15587

Figure 0.3 Number of required multiplexes and spare multiplex capacity available in each ΕΠΨΕ, assuming channels 61 – 69 are removed from the digital plan



As there could be benefit in releasing additional spectrum on a nationwide[3] basis, e.g. for use by PMSE or broadband wireless access, we attempted to identify the largest contiguous block of spectrum that could be removed in addition to the proposed harmonised band without compromising the ability to deliver the required national and regional services in each region. We found that the release of the contiguous block of spectrum comprising channels 28 – 32 inclusive could achieve this objective. In ΕΠΨΕ 1 it may be necessary to make use of one of the "spare" frequencies in the GE-06 plan that is not currently used in the Greek digital frequency plan, however the shortfall may not arise in practice as there are fewer regional stations in practice (declared by broadcasters) than have been officially licensed.

Figure 4 below shows the impact of removing channels 61 – 69 and channels 28 – 32 on the number of frequencies available for each SFN in the Greek digital frequency plan.

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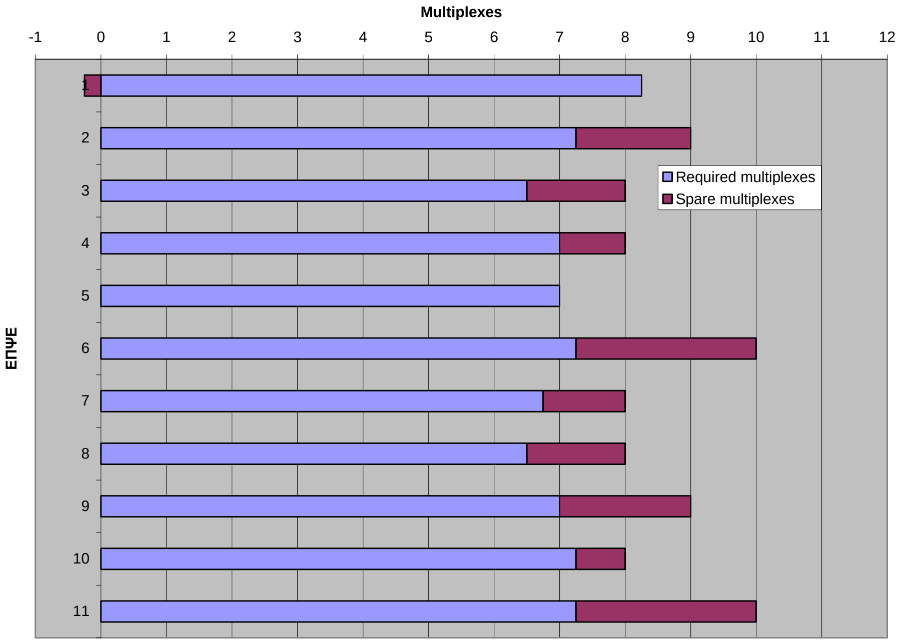
[3] Note this will not be on a harmonised basis

Figure 0.4 Number of required multiplexes and spare multiplex capacity available in each ΕΠΨΕ, assuming channels 61 – 69 and 28 – 32 are removed from the digital plan

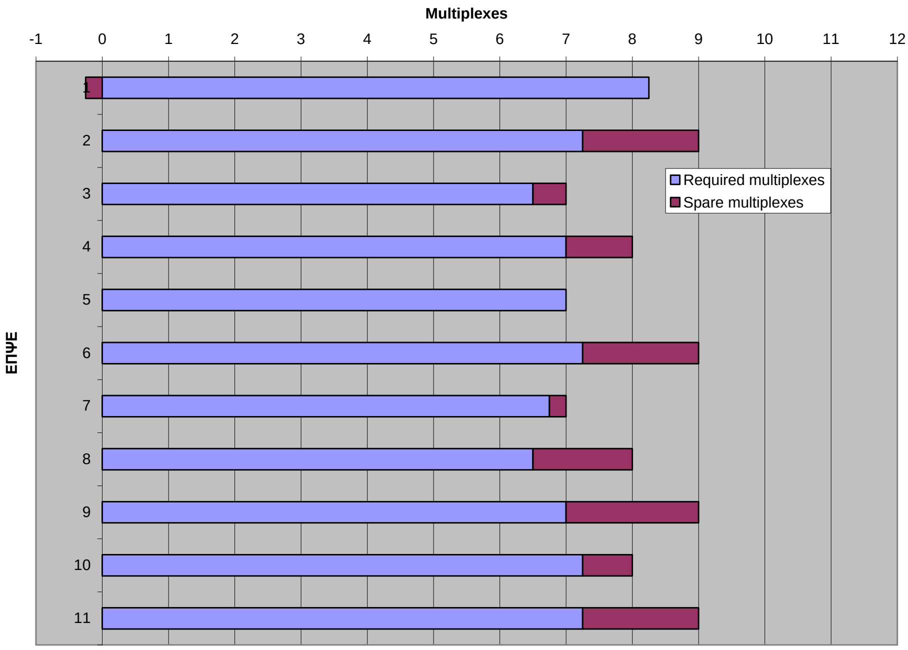


The utility of the harmonised digital dividend spectrum in Greece is highly dependent on the entire frequency band being made available, preferably on a national basis. Our understanding from EETT is that availability of the upper three channels (838 – 862 MHz) might be constrained due to ongoing use by the military. A number of options exist for dealing with this military use, including:

- migrating the military use to a similar sized block (24 MHz) below 790 MHz
- retaining 8 MHz of the military use in channel 65 (the duplex gap in the proposed harmonised mobile band) and migrating the remaining 16 MHz to below 790 MHz
- Migrate to another band and/or technology (several other countries have migrated equipment from the 610 – 960 MHz band to other core military bands)

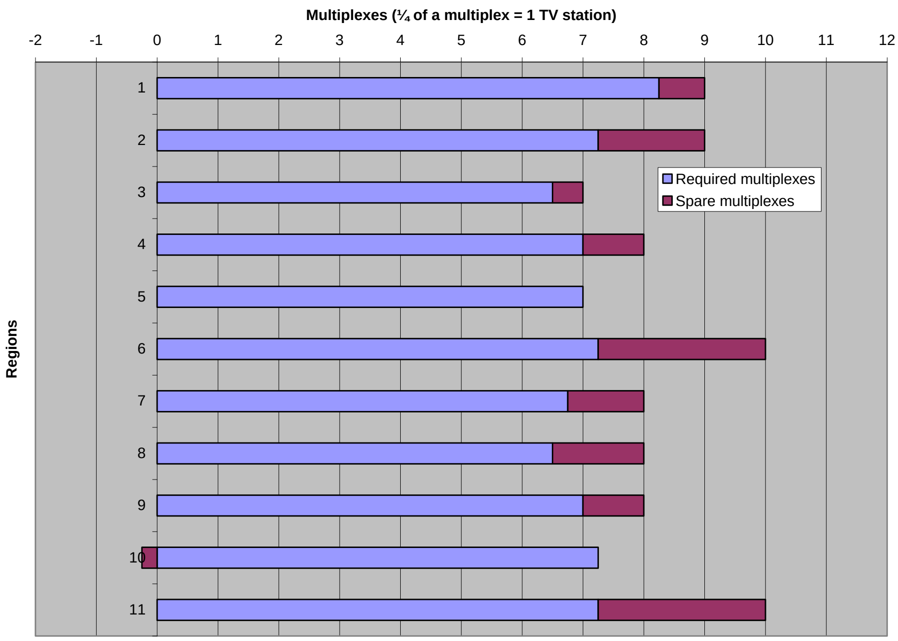
Adopting the second option appears to have minimal impact on the ability to deliver the required multiplexes (see figure below).

Figure 0.5 Number of required multiplexes and spare multiplex capacity available in each ΕΠΨΕ, assuming channels 61 – 69, 57 – 58 and 28 – 32 are removed from the digital plan



Migrating the military to a similar sized block (24 MHz), depending on the channels chosen, also only impacts on one ΕΠΨΕ, as shown in the figure below.

Figure 0.6 Number of required multiplexes and spare multiplex capacity available in each ΕΠΨΕ, assuming channels 61 – 69 , 50-52 and 30 – 32 are removed from the digital plan



Any cost incurred by the military could if necessary be recouped as part of the spectrum award process.

Conclusions

Our analysis has shown that the release of the frequencies above 790 MHz will have no substantial impact on the ability to deliver all the digital TV stations required under Greek legislation.

However, if channels 67 – 69 are not made available the amount of spectrum for mobile broadband services will be reduced to just 2 x 5 MHz and much of the benefit will be lost. Migrating military use to channels 57, 58 and 65, for example, would largely overcome this problem.

Of lesser benefit, compared with the digital dividend, it may also be possible to release further channels (e.g. 28 – 32) but these would not be harmonised. They could prove useful for PMSE, public safety, or new broadcast services such as HDTV.

0.6 Technology and market developments relevant to the digital dividend

A number of ongoing developments are driving interest in the digital dividend and may be able to facilitate the release of spectrum, for example, by enabling digital TV services to use spectrum more efficiently. The improved performance and lower cost of 3G services has stimulated the market for mobile broadband so that in some markets mobile technology has a significant share of the wider broadband market. For example, in Greece mobile broadband penetration is almost twice the EU average and mobile accounts for approximately half of all broadband connections[4].

The need for cost effective wireless broadband in rural areas is also reflected in the Government's Strategy for Electronic Communications and ICT for the period 2008-2013, announced in February 2008. In more remote areas the emphasis will be on wireless access and cost effective rollout in these areas will depend on access to sufficient spectrum in harmonised bands below 1 GHz.

In the broadcast sector, the recently-adopted DVB-T2 standard offers the potential to increase channel capacity by as much as 50% without changing the planning assumptions. The technology is designed from the outset to be received by existing domestic DVB-T antenna systems and to co-exist with existing DVB-T transmissions. Whilst there are concerns relating to the availability of transmitter and consumer equipment and the potential delay to DTT roll-out, the advantages in spectrum efficiency of the DVB-T2 standard seem to be so great that it might be unfortunate to entrench the older standard at this late stage.

[4] source: COCOM08-41 Final, EC Communications Committee Working Document on Broadband access in the EU: situation at 1 July 2008

There is strong interest in the US in particular in the deployment of "cognitive" radio technologies in parts of the TV broadcast spectrum. These technologies take advantage of the gaps in utilisation of the UHF frequencies, by detecting which frequencies are in use for TV transmission at a particular location and using the remaining frequencies for relatively low power transmissions that could be used for fixed or mobile wireless applications. Although more work needs to be done to confirm the compatibility of these devices with high density broadcast networks and other applications such as PMSE they may be suitable in the longer term for delivery of wireless broadband services.

Conclusion

Cost effective expansion of mobile broadband services is likely to depend on access to additional spectrum below 1 GHz, which in practice means the harmonised 790 – 862 MHz band. The relatively low level of fixed broadband availability, the absence of a cable broadband platform and the Government's commitment to rural wireless broadband in its strategy for electronic communications and ICT all strengthen the case for releasing the harmonised digital dividend in Greece.

0.7 International Coordination Issues

If the majority of the neighbouring countries to Greece adopt the harmonised approach to release 790 – 862 MHz for non-broadcasting applications such as mobile services there will be relatively few restrictions on the spectrum use. Cross-border agreements are already established for mobile services in other frequency bands and it should be feasible to do the same for the 790 - 862 MHz band. However it currently seems likely that Italy at least may decide not to adopt the harmonisation proposal and may retain high power broadcasts in the band.

In practice, our analysis indicates that the impact of continued Italian use of the sub-band for DTT on mobile use in Greece would be limited predominantly to mountainous areas with relatively sparse population. An exception may be the island of Corfu and it may be prudent to undertake a monitoring exercise there to assess the potential problem in more detail.

It should be noted that channels 67 – 69 are included in several digital allotments in other neighbouring countries at or near the Greek border. Although this will not be a problem if both Greece and the neighbouring countries adopt the harmonised digital dividend it may have an impact on any long term continued use of these frequencies by the military.

1 INTRODUCTION TO THE DIGITAL DIVIDEND

1.1 Background

The term “digital dividend” refers to the potential reduction in the amount of radio spectrum required to deliver terrestrial TV services when the transmission technology is migrated from analogue to digital. The reduction arises from the ability for digital technology to deliver a greater number of TV stations in a given amount of spectrum bandwidth, compared to analogue. Unlike analogue, which requires an entire 8 MHz frequency channel to transmit a single TV station, several digital stations can be transmitted on each frequency channel, in the form of a “multiplex”. Depending on the technology, a single multiplex may comprise four or more standard definition TV stations, one or two high definition stations, or twenty or more mobile television stations. Hence at each transmitter site, fewer frequencies are required to transmit a given number of TV stations in digital form than is the case with analogue.

In addition to this bandwidth saving, digital technology can also tolerate higher levels of interference than analogue, meaning that less geographic separation is required between co-channel transmitting sites. It is also possible to use the same transmission frequency at multiple sites within a given region (typically up to approximately 100 km radius), providing the content being transmitted is the same. Both of these factors contribute further savings in the amount of spectrum required to transmit TV services in digital format.

Over the last five years interest has grown in the use of the digital dividend to support the wider rollout of non-broadcast services such as mobile broadband communications. Work is now underway to harmonise part of the digital dividend in European countries, to provide network operators and equipment vendors with a Europe-wide market, minimising the cost for provision of such services. Additional frequencies beyond the harmonised digital dividend may be available in some countries and could be used for a variety of other services, such as public safety communications, fixed wireless access or programme making and special events (PMSE).

This report reviews the current situation regarding digital switchover and the prospect for releasing and utilising a digital dividend within Greece and other European countries.

1.2 Services and Applications that could make use of the digital dividend

The four main service categories that have been identified as potential users of any digital dividend spectrum are:

- Public Mobile / Wireless Telecommunications services
- Public Safety services,
- Programme Making and Special Events (PMSE) services and
- Additional fixed or mobile broadcast TV services (standard or high definition).

The following table considers what spectrum within the TV broadcast bands might be best suited to these and other more speculative applications:

Table 1.1 Suitability of digital dividend spectrum for various applications

Service	**Suitable spectrum**	**Comments**
Mobile telephony / broadband	790 – 862 MHz	Proposed harmonised band agreed at WRC-07 and being promoted by EC and CEPT.. Need economies of scale so unlikely to be feasible for countries to adopt a non-harmonised approach.
Broadband access to sparsely populated areas	Anywhere in UHF band	Potential in some countries for a lower sub-band that could be used for fixed wireless broadband. Could be below the proposed harmonised mobile band (though equipment costs may then be higher), or mobile networks operating in the harmonised band could also be used to deliver fixed access in remote areas.
Public Safety Communications	Lower half of the bands	Ideally spectrum close to existing allocations which are 385 – 390 MHz paired with 395 – 400 MHz (e.g. New Zealand plan to use 494 – 502 MHz[5]).
PMSE	Interleaved spectrum within while space	May be more difficult to find suitable spectrum due to more intensive use by digital. Would require transmitter power

[5] See http://www.mcdem.govt.nz/memwebsite.NSF/Files/Ministers%20forums/$file/Radio-comms-for-PPDR.pdf

Service	**Suitable spectrum**	**Comments**
	spectrum FDD duplex split	restrictions for radio microphones Possibility of using central 12 MHz centre gap between the down and up-links of a mobile sub-band
	Below 790 MHz	UK have proposed to use Ch38 Note it is expected that large scale events would require more than 24 MHz of contiguous spectrum
Broadcasting (more programmes), local television, HDTV etc	Anywhere in the band VHF or UHF band “White spaces[6]” for low power transmitters e.g. local, in-fill	Use of DVB-T2 technology would provide extra capacity on the multiplexes of at least 30% which could support additional programmes, local television or HDTV.
Mobile TV	Middle of the UHF band preferred	Compromise between aerial efficiency and separation from 800 / 900 MHz mobile bands
Low power devices	White spaces	There is also the proposal to use cognitive radio in the white spaces which could allow higher powers to be deployed
Military communications	Currently in 790 – 862 MHz band.	Possibility of sharing with Public Safety in lower half of the bands or around 400 MHz.

[6] The term “white spaces” refers to operational TV broadcast frequencies that are not used for TV at particular locations but may be usable at those locations for other applications (see section 6.4 for a further information)

2 INTERNATIONAL ACTIVITIES AND DECISIONS

2.1 Introduction

The nature of TV broadcasting (in particular the use of high power transmitters on elevated sites to maximise reception coverage) necessitates an international approach to planning radio spectrum. A major re-planning exercise was undertaken in 2006 in the form of a 2-stage ITU Regional Regulatory Conference (RRC) to update the previous analogue plan. A key output from the RRC was a definitive list of frequency assignments and allotments for each country in ITU Region 1 (essentially Europe, Africa and the Middle East), referred to as the GE-06 (Geneva 2006) Plan. The assignments and allotments were intended to ensure that digital TV broadcasts and other compatible transmissions can be undertaken with minimal risk of interference between countries. In its concluding statements the RRC acknowledged that there would be a digital dividend arising from switchover, which could provide greater bandwidth to existing mobile and other services. It should be noted that it is possible to make changes to the GE-06 Plan through agreements with neighbouring countries.

At the ITU World Radio Conference in 2007 (WRC-07) the band 790 – 862 MHz was allocated to the Mobile Service on a Primary basis in Region 1, which includes Europe and Africa. All the countries in Region 1 will have a co-primary mobile allocation for the 790 – 862 MHz band from 2015 (in some countries this is already the position). The outcome of WRC-07 resulted in a call for compatibility studies with other primary services and at the next WRC in 2011 there is an Agenda Item (1.17[7]) that covers these compatibility issues.

2.2 CEPT Activities relating to the digital dividend

2.2.1 Overview

CEPT is currently concluding a number of parallel activities relating to the digital dividend in response to mandates from the European Commission (EC). These activities are summarised below and described in detail in Annex A.

Prior to the WRC-07 decision, the CEPT was requested by the EC to address the possibility of harmonising a sub-band for bidirectional mobile communications whilst assuring zero or minimum impact on the GE-06 plan and with a view to deployment of such services throughout the EU. International harmonisation of spectrum is

[7] WRC-11 Agenda item 1.17 'invites ITU-R to consider results of sharing studies between the mobile service and other services in the band 790-862 MHz in Regions 1 and 3, in accordance with Resolution 749 (WRC-07), to ensure the adequate protection of services to which this frequency band is allocated, and take appropriate action'.

crucial to ensuring the widespread availability of low cost mobile terminals, since the cost of terminals is very much a function of the economies of scale achieved in serving large international markets. The output of this work was CEPT Report 22[8], which concluded that the preferred sub-band for a harmonised digital dividend was the upper part of the UHF band and should include as a minimum channels 62 to 69 inclusive (798 – 862 MHz).

Following the WRC-07 decision, the EC issued a second mandate to CEPT on specific issues that required study in the 790 – 862 MHz band, which was identified for mobile services at WRC-07. This mandate focused on the following three areas relating to deployment of mobile and PMSE equipment in the 790 – 862 MHz band.

- Technical conditions
- Channelling Arrangements
- Cross-border co-ordination.

The current status is of the work is summarised in the following sections and addressed in more detail in Annex A.

2.2.2 Technical Conditions for Mobile Networks

Draft CEPT Report 30 has been input into the June ECC meeting for approval to go for public consultation. The report defines the least restrictive conditions based on the block edge mask (BEM) approach.

The block edge masks, however, do not provide full protection of victim services and to resolve the remaining cases of interference additional mitigation techniques may need to be applied and possible approaches are provided in Annex 4 of the draft report.

In adjacent geographical areas (co channel or adjacent bands), the BEM has to be applied in conjunction with other conditions necessary for the coexistence between ECN systems and other applications. This can be done at a national level by deriving power flux density (pfd) values for areas within the territory of one administration or with cross-border coordination developed by bilateral or multi-lateral agreements.

2.2.3 Task 2 - Channelling arrangements

Draft CEPT Report 31 has been input to the June ECC for approval prior to public consultation. This draft report provides information on the background considerations that resulted in the development of the preferred harmonised frequency arrangement which is 2 x 30 MHz with a duplex gap of 11 MHz and block sizes of 5 MHz paired and with reverse duplex direction (see the figure below). Individual administrations which do not wish to use the preferred harmonised

[8] Report B from CEPT to the European Commission in response to the Mandate on: “Technical considerations regarding harmonisation options for the Digital Dividend” on 1 July 2008.

frequency arrangement or do not have the full band available have the option of considering:

- partial implementation of the preferred frequency arrangements
- TDD frequency arrangement
- mixed TDD and FDD frequency arrangement, or
- implementation of a 1 MHz raster.

Figure 2.1 Band Plan currently proposed by CEPT for mobile services in the 790 – 862 MHz band

791-796	796-801	801-806	806-811	811-816	816-821	821 - 832	832-837	837-842	842-847	847-852	852-857	857-862
Downlink						Duplex gap	Uplink					
30 MHz (6 blocks of 5 MHz)						11 MHz	30 MHz (6 blocks of 5 MHz)					

The FDD duplex gap could be used for a number of possible services but the ECC has concluded that studies in CEPT should assume the use of wireless microphones noting that the resulting technical framework might also be used by other applications.

In addition a Draft ECC Decision on the harmonised conditions for Mobile/Fixed Communications Networks operating in the band 790 – 862 MHz was approved at the 32nd ECC PT1 meeting at the end of April to go to the ECC meeting in June for approval prior to public consultation.

2.2.4 Task 3: Cross border coordination issues

Draft CEPT Report 29 addresses cross-border co-ordination issues and the document received no comments before the closing date of the public consultation. The draft report notes that incoming co-channel and overlapping channel interference from broadcasting networks into mobile service base stations in areas adjacent to the border is likely to be the main issue. This is not surprising given the much higher power levels deployed by many broadcast transmitters relative to mobile base stations. The draft report also notes that if countries do harmonise the channels 61 – 69 for mobile services cross-border co-ordination will need to be developed similar to that specified in ECC Rec(08)02 for GSM and other services in the 900 MHz band.

The Draft Report defines trigger field strengths for international co-ordination, based on the GE-06 Agreement. The trigger levels for mobile base stations range from 8.2 to 18 dBµV/m, depending on the type of mobile system and whether a 10 metre or 20 metre antenna height is assumed.

2.2.5 PMSE

The Draft CEPT Report 32 has been submitted for approval to go out for public consultation at the ECC June meeting. The report investigates approaches needed to ensure that PMSE systems can continue to operate in the UHF band as well as alternative common solutions outside the UHF band.

In the draft report it is recommended that the PMSE applications in the 470 – 790 MHz band should primarily be the PMSE applications that require some protection (i.e. "Critical use"). This may be achieved by a "controlled" access to the spectrum and could be achieved by administrations via individual licensing regime (see ECC Rec. 70-03) or by specifying the type of equipments allowed to operate in this band. This could increase the efficiency of the spectrum usage and in most cases would provide sufficient amount of spectrum for average demand and in some cases also for peak demand.

2.2.6 Replanning of broadcast services to free up the 790 – 862 MHz band

A further report is being developed to provide guidelines to help administrations to re-channel broadcasting networks to use channels 21 – 60 where necessary and to release channels 61- 69 through bilateral / multilateral agreements. It also covers the situations where additional resources may be required for broadcasting in the UHF band, or where an administration does not wish to make a change because of a neighbouring country wishing to introduce a mobile service or to use additional resources for broadcasting.

The report is scheduled to be finalised at the next meeting of TG4 in September 2009.

2.3 European Commission (EC) activities relating to the digital dividend

The EC's Radio Spectrum Policy Group (RSPG), an advisory group on spectrum issues set up by the EC in 2002, is re-visiting one of its Opinion papers on the spectrum policy implications of digital dividend, RSPG Opinion 07-161[9], in light of developments in technology and applications. The RSPG review will examine how the digital dividend can be used on a technology and service neutral basis, while promoting new and innovative applications and services. It will also input to the EC to assist it in defining a digital dividend roadmap for Europe.

In November 2009, the RSPG plans to deliver a second opinion, concerning the ongoing debate on the co-ordination of digital dividend spectrum in Europe. The expectation is that this opinion will affirm that the EU needs more involvement in these matters. The opinion is also expected to recommend a range of methods for more effective spectrum usage. In the meantime, the EC is putting pressure on Member States to meet the deadline for the full transition to digital television by 2012. On 16th February, the EU executive explained that countries currently fall into three different groups:

[9] See http://rspg.groups.eu.int/doc/documents/opinions/rspg07_161_final_op_digdiv.pdf

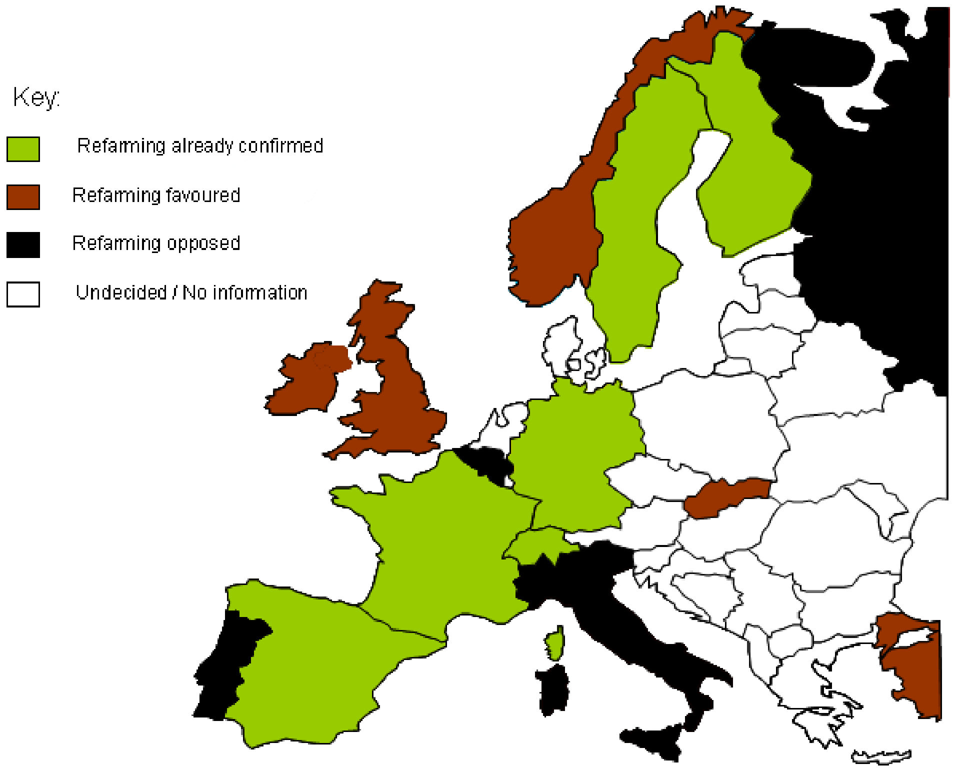
- Those where analogue TV has already ceased (Germany, Finland, Luxembourg, Sweden and the Netherlands),
- Those which intend to complete the transition by 2010 (Austria, Denmark, Estonia, Spain, Slovenia and Malta), and
- The other countries planning on making the transition by 2012.

3 STATUS OF THE DIGITAL DIVIDEND IN INDIVIDUAL EU COUNTRIES

3.1 Overview

To date six EU countries (Finland, France, Germany, Spain, Sweden and Switzerland) have already decided to release the 790-862 MHz band for mobile services. Other countries, including the UK, have expressed support for the principle of releasing this spectrum but others, such as Italy, are opposed to mandatory release, on the ground that they plan to make extensive use of these frequencies for digital TV. Reservations have been submitted to CEPT about the recommendation of Draft Report 22 by Belgium, Portugal, Russia and Spain. The map below shows the current position of EU and neighbouring countries on the release of 790 – 862 MHz, where this is known.

Figure 3.1 Position of EU and neighbouring countries on release of spectrum in the 790 – 862 MHz band



It was noted in a recent consultation document by the UK Regulator Ofcom on clearing the 800 MHz band[10] that *"from discussions we have held, we believe that a*

[10] See http://www.ofcom.org.uk/consult/condocs/800mhz/

number of other European countries are likely to follow suit over the coming months. The reason that these countries are planning to release more spectrum in the upper band is that, for various reasons, this spectrum is likely to be particularly suitable for new generations of mobile broadband services, though other uses are also technically possible."

Where countries are reluctant to adopt the harmonised spectrum, this is usually due to extensive reliance on these higher frequencies in the digital networks – e.g. Spain, which until recently did not support the digital dividend, has three national single frequency networks operating above 790 MHz which would need to be completely re-planned if the spectrum were to be re-farmed. In some cases it might not in reality be such a problem as we note that in, for example, Belgium, Germany and the Netherlands only a small percentage of the population use terrestrial networks as the primary source of TV with the majority using cable. There are therefore likely to be strong economic arguments to make the upper band available for other technologies.

A more detailed consideration of the situation in some individual EU countries is presented in section 3.3.

3.2 Typical DTT multiplex requirements in European countries

The RRC-06 planning process required each Administration to submit their digital requirements and in the GE-06 plan there are a number of examples where there has been a large number of frequency channels associated with a particular transmitter site or allotment area. In practice some countries are now planning to use substantially fewer frequencies than were included in the GE-06 plan which should provide more flexibility in releasing channels 61 – 69.

In order to ensure equitable access to the UHF spectrum, each country was allocated a specific number of national "layers" to provide DTT services. A layer is essentially a set of frequency assignments or allotments which can provide the capacity of a single 8 MHz channel across the whole of the country. Examples of 'layers' can include:

- a multi frequency network (MFN) providing ubiquitous coverage for a national multiplex using a different frequency at each transmitter site or allotment area
- a national single frequency network (SFN), providing universal coverage for a single multiplex using the same frequency at every location
- a set of assignments intended to allow the operation of local or regional multiplexes that collectively cover the country completely

Under the GE-06 plan, most countries were awarded 7 or 8 national DTT layers in the UHF band and one national DTT layer in the VHF band.

The table below provides information on the number of layers received[11] by each country at RRC-06 in the UHF band and (where available) the latest information on the number of multiplexes planned in each country. There were no indications as to the expected use after analogue switchover as most Member States considered it premature to draw any conclusions at the stage of the initial development of DTT.

Table 3.1 Number of national DTT Layers allocated to each country under the GE-06 plan

Country	Layers	Current Plans
Austria	7	Expected to have 6 in total
Belgium	7	Expected to have 8 in total in Flanders region
Czech Republic	7	Expected to have 4 in total
Denmark	7	At least 5
Finland	7	4 Multiplexes were operating in Oct 2008 but expected to have 6 multiplexes for DTT, 2 for DTT local and 2 for HDTV DTT.
France	8	Currently 7 multiplexes (5 SDTV plus 1 HDTV and 1 mobile TV) but there are plans to extend this to 13 through bilateral negotiations. These will comprise 11 DVB-T networks (95% population coverage) and 2 DVB-H networks (70% population)
Germany	7	
Hungary	7	5 multi[lexes
Ireland	8	Expected to have 6 in total.
Italy	8	8 Multiplexes were operating in Oct 2008 but no indication of expected number in total after switch over
Latvia	7	
Lithuania	8	
The Netherlands	7	5 multiplexes
Norway	7	
Portugal	7	Expected to have 6 multiplexes in total

[11] source: Annex 1 to the draft RSPG Opinion on "EU Spectrum Policy Implications of the Digital Dividend" .

Country	Layers	Current Plans
Romania		Expected to have 8 multiplexes in total
Slovakia	7	
Slovenia	7	
Spain	12	5 Multiplexes were operating in Oct 2008 but no indication of expected number in total after switch over
Sweden	7	Currently 6 multiplexes have been licensed. Expected to have 7 in total.
Switzerland	7	6 multiplex for DVB-T in some regions. Also DVB-H[12]
UK	8	6 - allows DTT to match analogue coverage and to expand capacity to around 10 times that of analogue

Note: The information on expected total multiplexes is mainly obtained from EPRA Information paper on status of digital television. 28th EPRA Meeting, Dublin, 29 – 31 October 2008. Document EPRA/2008/12.

It can be seen that in most countries 7 or 8 national layers have been allocated.

3.3 Current status of the digital dividend in specific EU countries

Many EU countries have commenced their switchover from analogue to digital TV and some have already switched off the analogue transmissions. The flexibility to accommodate a digital dividend, especially where this is harmonised with other European countries, varies from country to country depending on the extent to which the affected channels are used for digital TV and the importance of terrestrial TV relative to other platforms such as satellite or cable. The following sections summarise the current status of the digital dividend in a number of European countries.

3.3.1 Belgium

In Belgium, 97% of the population use cable systems to access TV programmes. 60,000 homes are dependent on the terrestrial platform for primary TV viewing and up to 180,000 households access TV using both cable and over the air TV. An impact analysis undertaken by Belgium concluded that the introduction of a sub-band for non-broadcast applications would have a significant impact on existing broadcast services. In particular, it is noted that there a disproportionately high number of allotments in the plan using channels located in the upper part of the 470 – 862 MHz band. The report also states that a significant re-planning of the GE-06

[12] See http://www.dvb.org/about_dvb/dvb_worldwide/switzerland/index.xml

allotments would be needed for Belgium to accommodate a harmonised digital dividend and this is not considered acceptable to the communities in Belgium. Belgium has 14 GE-06 allotments in total, 5 of which can deliver at least 5 multiplexes. If channels 61 – 69 are refarmed, no allotments can deliver more than 3 multiplexes, so there would be a considerable impact on UHF DTT provision in Belgium.

3.3.2 France

A study conducted by Analysys and Hogan & Hartson[13] examined the most efficient way of using the spectrum released by the digital switchover in France, which is expected to take place before the end of November 2011. The study considered two distinct scenarios. In the first scenario (referred to as 'sharing the digital dividend'), it was assumed that the part of the spectrum is allocated to services other than broadcasting (e.g. mobile TV and mobile broadband) and in the second scenario (referred to as 'audiovisual only'), it is assumed that the entire spectrum was allocated to the broadcasting service.

The results showed that the first scenario satisfied the quantitative tests set by the French parliament for digital television (i.e. minimum number of multiplexes and minimum population coverage). Therefore, it was concluded that allocating a sub-band of the UHF frequencies to other services ensures more efficient use of the spectrum. In line with the study results, the French Digital Dividend Commission presented its recommendations to the Prime Minister on the 23rd July 2008. According to these main recommendations, the sub-band 790 – 862 MHz should be offered to provide national fixed and mobile high speed broadband services and France should be in favour of harmonising the sub-band 790 – 862 MHz for mobile services in the EU.

There will be a need to migrate military systems from the 830 – 862 MHz band. In the past it has been necessary to migrate the military from the 1800 MHz and 2 GHz bands – see Annex C for more details. The cost of the refarming was paid through a refarming fund managed by the regulator (ANFR) and the Ministry of Defence planned the refarming operation in a five to six year plan. There is still the potential to adopt the same approach for the 830 – 862 MHz band with money being advanced to the military and then having the operators, for example, paying back the fund. Although in practice this may not be necessary depending on the age of the equipment and the possibility to continue to utilise the spectrum, on a limited geographic basis, while migrating to alternative spectrum.

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[13] See http://www.analysysmason.com/PageFiles/4324/Valuation%20of%20the%20digital%20dividend%20in%20France%20(English%20Version).pdf for the Executive Summary in English

3.3.3 Germany

In Germany 95% of German households have access to TV services via cable and satellite. The telecommunications industry has put pressure on the German States[14] to allow part of the UHF spectrum to be used for other services, for example providing broadband services to rural areas. In CEPT Report 22 it was noted that Channels 61 – 63 and 67 – 69 are currently used by the military but that there may be civilian use in the near future for these channels.

In February 2009 the German Government announced plans to use a large portion of the digital dividend, as part of a larger strategy, to support broadband services[15] and ensure broadband access for all households in Germany by 2010. It was proposed to use the spectrum, which will be auctioned, to enable operators to deploy wireless and mobile broadband services in rural areas that are currently outside the reach of DSL or cable.

The proposed changes to the frequency plan to allow for non-broadcasting use of the digital dividend spectrum received State approval (a Bundesrat decision) in June 2009.

3.3.4 Ireland

The Irish regulator, ComReg, has released a consultation document entitled "Digital Dividend in Ireland - a new approach to spectrum use in the UHF Band." [16] ComReg is of the view that Ireland's digital dividend can boost the country's economy and therefore wants to optimise the amount of spectrum that is released, taking into account:

- the EC proposal for a harmonised non-mandatory sub-band from channels 61 to 69 for non-broadcasting applications, and
- the requirement under existing nationally legislation to provide 6 DTT multiplexes

The consultation explores three main digital dividend spectrum proposals:

- Mixed usage of the UHF band by broadcasting and non broadcasting applications
- Use of the channels 61 to 69 for non-broadcasting services on a service and technology neutral basis, and
- Possibility of releasing further spectrum within the channel range 21 to 60 (e.g. channels 36 and 38) on a service and technology neutral basis.

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[14] Sixteen state governments (Lander) control and allocate broadcasting spectrum.

[15] See http://www.telecompaper.com/news/article.aspx?cid=659108#

[16] See http://www.comreg.ie/_fileupload/publications/ComReg0915.pdf . The Consultation Document was released on 12 March 2009.

In the case of the additional sub-band it is noted in the consultation that this would require further adjustment of the spectrum reserved for broadcasting and would need to be evaluated on the technical and economic merits. Also decisions made by other administrations would influence the availability of equipment for non broadcasting applications but currently such proposals are unclear except a proposal from the UK to clear a lower sub-band comprising channels 31 to 37 inclusive.

3.3.5 Italy

It was reported in a recent Study by Europe Economics for Irish Regulator ComReg[17] that Italy's communications regulatory authority (Agcom) has allocated the first major portion of the DTT spectrum, on an equal basis, to the 3 main terrestrial broadcasters (RAI, Mediaset and Telecom Italia Media). Also the decisions of Agcom as well as of the Ministry of Telecommunications strongly hint that spectrum available after switchover will be used largely or solely for broadcasting purposes. This is consistent with comments that Italy is reluctant to have a common European strategy for the Digital Dividend and spectrum in general[18].

3.3.6 The Netherlands

CEPT report 22 noted that the harmonisation of the upper part of the UHF band will be constrained as 5 multiplexes are already licensed until 2017 and use all available frequencies. Some frequencies are not available during the transition phase due to the protection requirements of analogue TV and existing military use in neighbouring countries. These frequencies are expected to become available in 2012, after which it should be technically possible to release at least part of the 790 – 862 MHz band for other services. However the amount of spectrum that could be made available may be limited to 6 x 8 MHz.

3.3.7 Slovakia

Slovakia has recently undertaken a consultation[19] on digital TV which included the potential use of 790 – 862 MHz for mobile broadband services.

3.3.8 Spain

As noted earlier the release of the upper portion of 470 – 862 MHz is likely to be difficult due the widespread use of these channels for digital TV in Spain. Spain's reservations about the harmonisation proposal, noted in CEPT Report 22, stated that the release of channels 62 – 69 was the worst of the four release options

[17] "How Ireland can best benefit from its digital dividend, Europe Economics

[18] Report from Policy Tracker titled: "Regulators chairman campaigns for digital spectrum release" , February 2009.

[19] See : http://www.teleoff.gov.sk/index.php?ID=1501

originally considered for Spain. After switchover new multiplexes will be allocated and Spain indicated that 5 layers will need to be allocated to DVB-T in the channel 61 – 69 range taking into account that 7 multiplex are already operational. Also all the existing Digital Terrestrial TV layers use some frequencies in the upper part of the spectrum and this includes 4 nationwide SFN multiplex in the channels 66, 67, 68 and 69.

However despite these issues Spain has decided to release the 790 – 862 MHz band for mobile services.

3.3.9 Sweden

Digital switchover was completed in Sweden in October 2007and it was decided that spectrum the 790 - 862 MHz band will be auctioned and allocated for other services. The broadcasters had initially requested access to the entire UHF band to allow for the migration of the DTT platform from MPEG-2 to MPEG-4, along with the possible transition to DVB-T2.

3.3.10 Switzerland

Digital switchover in Switzerland was completed in 2008. It has been decided to allocate the 790 – 862 MHz band to mobile broadband. The Swiss government said use of this spectrum will enable excellent mobile broadband coverage of rural areas while offering good penetration into buildings.

3.3.11 Turkey

Turkey has indicated its support for the harmonisation of the upper band of 470 – 862 MHz[20].

3.3.12 UK

The UK was the first country in Europe to plan specifically for the release of a digital dividend on completion of digital switchover. In 2003 the regulator announced plans to release a smaller, upper band of 48 MHz in the range 806-854 MHz (channels 63-68); and a larger, lower band of 64 MHz between 550 MHz and 630 MHz (channels 31-35, 37 and 39-40). This was prior to any moves at European level to harmonise the digital dividend. However, in the recent consultation Ofcom[21] is proposing to clear Channels 61 and 62, which were originally planned for DTT and Channel 69 which is used for PMSE (including radio microphones) to align the upper digital dividend band with CEPT's harmonised band. As a consequence, Ofcom has proposed that PMSE use should migrate from channel 69 to channel 38.

Currently approximately 1,700 users are licensed to use channel 69 in the UK and these account for most wireless microphone users. Wireless-microphone users in

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[20] CEPT Report 22, Annex A6

[21] See http://www.ofcom.org.uk/consult/condocs/800mhz/800mhz.pdf

the UK place great value on channel 69 because it is adjacent to interleaved spectrum in channels 67 and 68 which are currently used for analogue terrestrial television but not heavily so. This means they afford microphone users access to the 24 MHz in channels 67-69 on a near-UK-wide basis. It was therefore important to identify alternative spectrum and a number of different options were considered, including:

- Interleaved spectrum. There are technical similarities with Ch 69 and availability of equipment across the UK. The main concern was that with more intensive use of the lower channels it may become more difficult to find suitable interleaved spectrum for PMSE.
- Channel 38. This can provide 8 MHz of spectrum on a UK-wide basis and will be next to interleaved spectrum in and above channels 39 and 40 so is very similar to Ch 69.
- FDD duplex split. The possibility of using the 12 MHz centre gap between the down and up links of the mobile sub-band is under consideration and is it would need to be used by low power devices it would be suitable for wireless microphones. If this approach is adopted across much of Europe it could offer economies of scale. The issue is when it would be possible to start using this spectrum.
- Channel 70 (862 – 870 MHz). This has been identified for greater licence – exempt use and would not be suitable for professional requirements.
- 1785 – 1800 MHz. This spectrum is allocated to digital wireless microphones but not currently used.

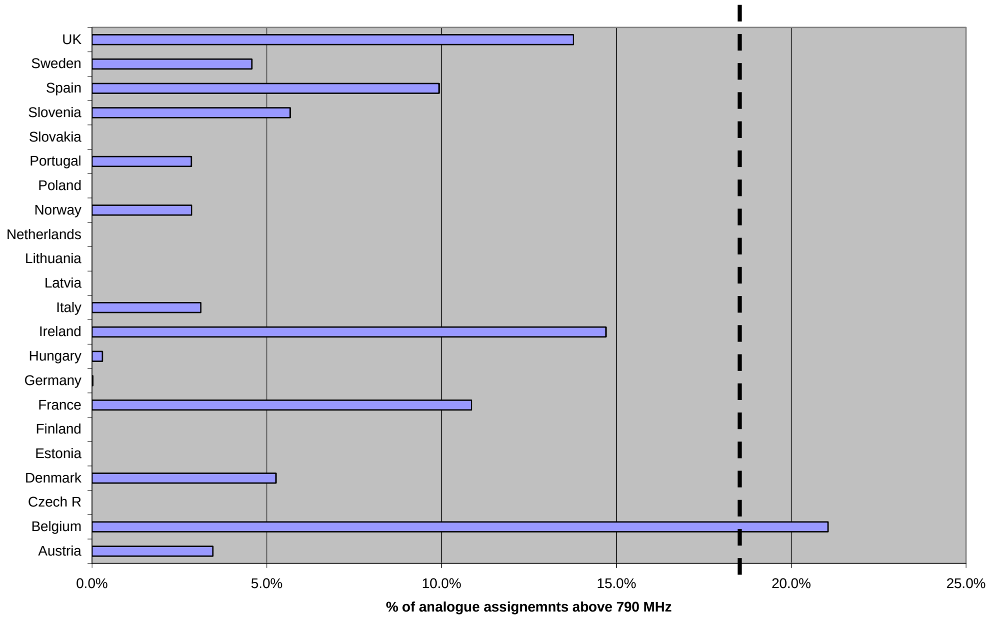
Ofcom has consulted on Channel 38 which they consider to be the preferred option technically, economically and on the basis of coverage.

This proposed solution will reduce the amount of spectrum that can be cleared in the lower part of the band (now channels 31 - 37). In the Ofcom consultation it is mentioned that identifying harmonised spectrum in the lower bands is likely to be very difficult.

3.4 Extent of analogue broadcasting in the 790 – 862 MHz band

It is interesting to note that there is limited use of the 790 – 862 MHz spectrum for analogue TV assignments. This was due to the band 790 – 862 MHz being allocated to other services such as mobile and fixed in a number of countries. The figure below compares the percentage of UHF assignments in each country that are in the 790 – 862 MHz band. If the channels were uniformly distributed throughout the band the expected percentage would be 18.4%. It can be seen that in many countries, as Greece, there are no analogue TV assignments and in most others there are relatively few compared with the rest of the UHF band.

Figure 3.2 Percentage of analogue UHF assignments in channels 61-69



3.5 Other Uses of the UHF Band in European Countries

A number of countries have part(s) of the UHF band that are currently allocated to other (non-broadcast) uses such as military, radio astronomy or PMSE services. The following sections review the extent of such use and the likely impact on digital switchover and the digital dividend.

3.5.1 Military Use

According to information available on the European Radiocommunications Office Frequency Information System (EFIS)[22] there are a number of countries that currently have Defence systems operating in the upper part of the UHF band. However only Belgium, France and Germany specifically requested protection of these systems under the GE-06 frequency plan.

Table 3.2 Current Military use of UHF spectrum in Europe

Country	Frequency Range (MHz)	Usage
Belgium	830 – 862	Tactical radio relay
Bulgaria	766 – 814, 822 - 862	Defence systems (shared with DTT)
Cyprus	790 – 862	Defence systems
Denmark	790 – 814, 838 - 862	Tactical radio relay
Finland	790 – 822, 838 - 862	Defence systems (shared with DTT)

[22] http://www.efis.dk/views2/search-general.jsp;jsessionid=FFE34B2B33D86B8740C922B661BD4C17

Country	Frequency Range (MHz)	Usage
France	830 – 862 MHz	Limited military use at specific sites, expected to cease by 2012
Germany	790 – 814, 838 - 862	Tactical radio relay, expected to cease by 2012
Hungary	798 – 814, 830 – 846	Aeronautical military systems
Latvia	790 - 862	Tactical radio relay (shared with DTT)
Lithuania	790 - 862	Defence systems (shared with DTT)
Poland	790 – 814, 830 -838, 846 - 862	Aeronautical military systems
Romania	766 – 790, 790 – 838, 838 - 862	Defence systems (shared with DTT)
Slovakia	790 – 806, 806 – 808 838 - 862	Aeronautical navigation Defence systems (shared with DTT)
Slovenia	790 - 890	Defence systems

In the latest version of ERC Report 25, "European Table of Frequency Allocations and Utilisations Covering the Frequency range 9 kHz – 275 GHz"[23], dated May 2004, it is mentioned that CEPT Administrations agreed to clear the band 645 – 960 MHz of assignments to aeronautical radionavigation service by 2008. Also in the bands 790 – 838 MHz and 738 – 862 MHz there is a footnote (EU2) indicating civil military sharing of the spectrum.

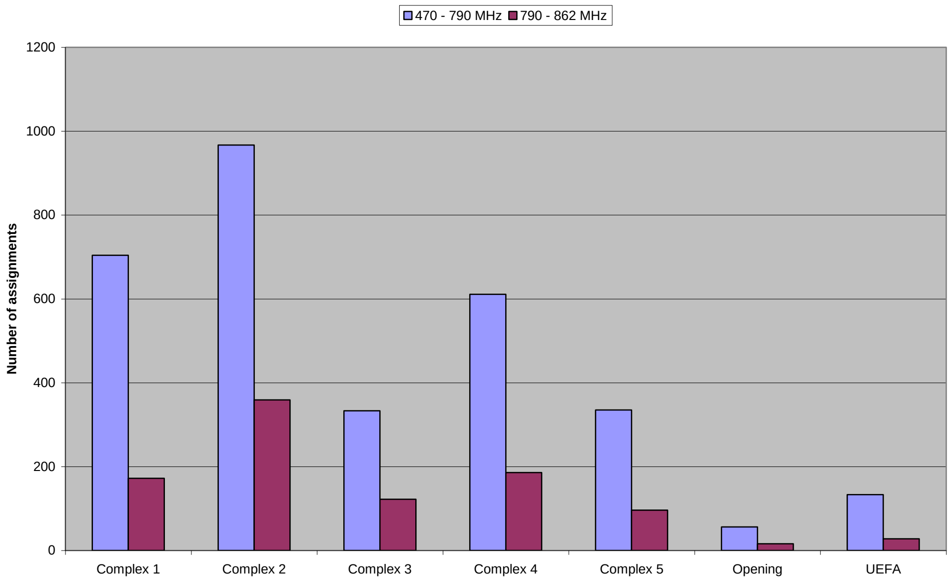
3.5.2 Programme Making and Special Events services (PMSE)

The 470 – 862 MHz band is of great importance to broadcasters for PMSE services, in particular radio microphones, in-ear monitoring, portable audio links, talk-back, wireless intercom, mobile and temporary audio links. For example, in the UK the 470 – 862 MHz range accounted for 58% of all PMSE frequency assignments in 2006 and in Greece there is already first hand experience of the demand posed by major events such as the 2004 Olympics. The alternative frequency band 1785 – 1800 MHz which was made available for digital radio microphones, in-ear monitoring and portable audio links is rarely used and has been allocated to other use in some countries Furthermore, the requirement for PMSE services is increasing, reflecting growth in the number of TV and radio channels and major sporting and cultural events. Digital switchover will have a significant impact on PMSE, since digital technology enables more intensive use of frequencies than analogue.

[23] See http://www.erodocdb.dk/docs/doc98//official/pdf/rep025.pdf

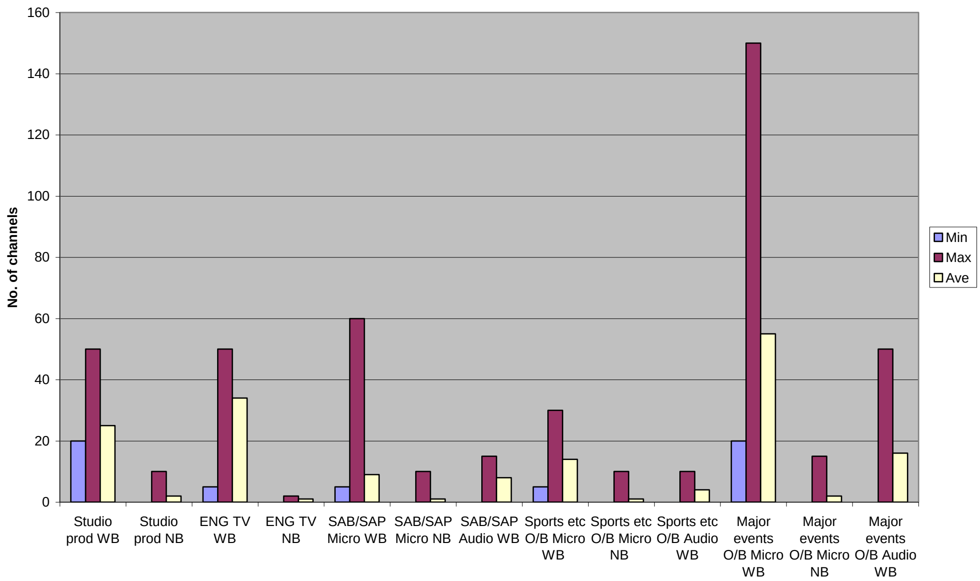
It can be seen in the figures below that there was considerable use of the 790 – 862 MHz band during the 2004 Athens Olympics.

Figure 3.3 Channels assigned to PMSE during the Athens Olympics in 2004



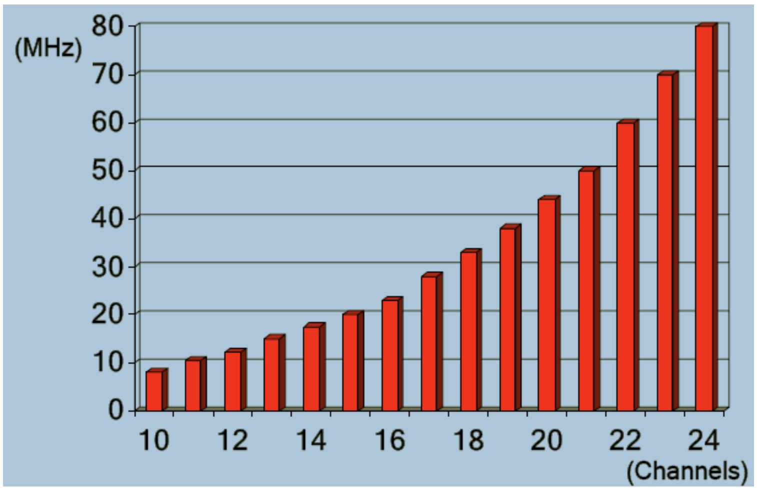
EBU Technical Report 001, "Results of the EBU questionnaire on spectrum requirements for SAB/SAP & ENG/OB applications", included an estimation of frequency requirements in 2012 which, compared with CEPT ECC Report 2, published in 2002, are higher in almost all cases. The figure below shows the estimated demand for radio-microphones, in-ear monitoring and portable audio links for various applications. The estimates are provided for both wide-band (200 kHz) and narrow-band (15 kHz) channels.

Figure 3.4 Broadcasters' Prognosis (October 2008) of future situation for Radio-microphones, in-ear monitoring and portable audio links



Currently analogue wireless microphones dominate the PMSE market as they have high audio quality and reliability, transmit in the real time (no digital compression delay) and, because of economies of scale and well-established products, relatively low cost. The down-side is that they cannot be used adjacent to each other simply by dividing the spectrum into equally spaced channels because of limitations due to intermodulation products. The figure below provides an indication of spectrum requirements and it can be seen that as the number of channels in use at a venue increases the amount of bandwidth required increases disproportionately.

Figure 3.5 Recommended channels per MHz for analogue wireless microphones (Source: Sennheiser)



It will be essential that sufficient spectrum is made available for PMSE, especially as the availability of interleaved spectrum may be reduced through switchover. It may be necessary to consider the use of alternative technologies and spectrum.

Digital wireless microphones are relatively new and all the channels can be used but the biggest challenge is the latency (delay) due to converting the audio signal to digital and the need for compression to reduce the bandwidth. The biggest challenge for digital is when wireless microphones are used in high-end professional usage scenarios and it is essential that there is audio / performer lip synchronisation. Digital equipment is used in the US, on a limited basis, without compression and bandwidths up to 800 kHz are required compared with 200 kHz for FM in Europe. The timescales for mainstream adoption of digital technology are expected to be between 7 and 10 years.[24]

Another important consideration for PMSE is tuning range especially for professional users where there may be contiguous channels that can be used for PMSE. Wideband tuners however have significant disadvantages in highly

[24] Source: "Potential for more efficient spectrum use by wireless microphones", by CSMG, 4.11.2008. See http://www.ofcom.org.uk/radiocomms/ddr/documents/wirelessmics.pdf

congested RF environments as they are more likely to pick up interference than narrow band. High-end analogue professional microphones can typically tune over 24 to 36 MHz (3 – 4 TV channels) and are expensive while cheaper products will have significantly less flexibility. There are products available that can cover the frequency range between 450 and 960 MHz using selectable receiver units with 90 MHz bandwidths. Manufacturers, to reduce development and manufacturing costs and optimise economies of scale, prefer to produce systems that are capable of operating over a broad range of frequencies and so are applicable to multiple / global markets. In some countries, such as the UK[25], specific channels were also identified for PMSE. Ideally the outcome of the switchover to digital should take into account the need for sufficient spectrum to be made available to PMSE in the VHF and UHF bands especially as the PMSE industry has a limited market compared with, for example, cellular and it is difficult to take advantage of economies of scale.

3.6 Licensing approaches for digital TV

3.6.1 Introduction

We have been asked by EETT to assess the current approach to licensing DTT in Greece, in terms of how this compares with other countries and whether there may be scope for improvement to the licensing process. Whilst a detailed analysis of licensing would involve significant additional work and is beyond the scope of the current study, we present in the next sections a summary of the different approaches to DTT licensing and some examples of the process that has been followed in individual countries.

3.6.2 How to license?

One of the main aims of spectrum licensing is to ensure efficient use of the limited available spectrum. For digital TV it is important that the licensing approach encourages the adoption of more spectrally efficient technologies while ensuring the required level of TV coverage and services is maintained. It is also important for the regulator to ensure that consumers are aware of the hardware (set top boxes, antennae etc) that is required to ensure continued reception of TV after switchover.

As already noted, a fundamental difference between analogue and digital broadcasting is that multiple TV stations can be accommodated on a single frequency channel. Some large broadcasters such as ERT may provide sufficient programme channels to make up one or more entire multiplexes and in such cases it is practical to grant a licence to the broadcaster that includes the right to use specific frequencies for the transmission of the multiplex(es). However, for smaller broadcasters there will be a need to share a multiplex with other broadcasters and

[25] In the UK channels 67 – 69 were used with ch 69 being used for 6.42% of the assignments during 2006.

this raises the question of how to license the frequencies on which the multiplexes transmit.

Essentially there are two options available, namely:

i) license the frequencies to one or more individual multiplex operators, who then make capacity available to individual broadcasters either on a commercially negotiated basis or under direction from the regulator

ii) license the frequencies directly to individual broadcasters who are then required to make the necessary arrangements to combine their content onto one or more multiplexes.

In most countries, the frequencies are licensed to multiplex operators, who have some freedom to vary the parameters of the multiplex. Making more efficient use of the licensed frequencies (e.g. by using improved technology to accommodate additional stations) the multiplex operator can increase its revenue (since broadcasters generally pay a commercially negotiated or regulated rate for multiplex capacity) and there is therefore an incentive to improve efficiency.

Where frequencies are awarded directly to the broadcasters (as in Greece) and the multiplexes are effectively operated by a consortium of said broadcasters, there is unlikely to be any incentive to improve efficiency as freeing up capacity for other market entrants would be counter to the interests of the existing broadcasters.

3.6.3 To what extent is technology mandated by the licensing process?

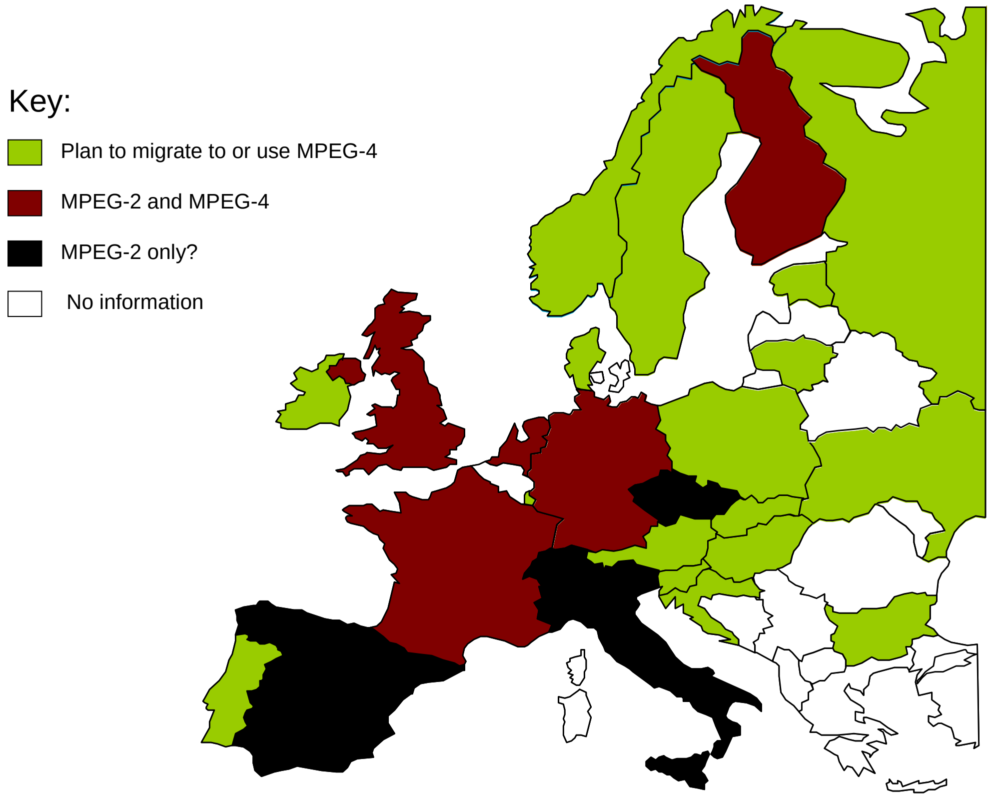
Although there has been an increasing trend in other sectors of the electronic communications market towards making licences technology neutral and allowing the market to decide on the optimum solutions, this is not generally the case for digital TV. There are sound reasons for this, in that would be virtually impossible to roll out DTT without prior agreement on parameters such as coding, modulation, interactivity and Service Information to ensure that set top boxes and electronic programme guides operate smoothly across all the multiplexes. There are also increasing moves to specify more efficient compression, coding or modulation schemes to ensure DTT networks are compatible with new services like HDTV.

For example in Croatia the recent tender for two DTT multiplexes stipulated the use of MPEG-4 and in Denmark the Radio and Television Board have called for all four existing Multiplexes eventually to upgrade from MPEG-2 to MPEG-4 with the first Multiplex having to implement this by 2012.

The reason for specifying the compression in this way is so the retailers and consumers are aware of the compression requirements placed on the set top boxes (receivers). In the future it may be less important to specify such parameters as newer generations of set top box or integrated receivers themselves become more flexible.

The map below provides an indication of the different compression formats that have been adopted to date. Further information is provided in Annex B.

Figure 3.6 Adoption of MPEG-2 and MPEG-4 in EU and neighbouring countries



In contrast the modulation scheme is not always specified although there may be implications in terms of coverage or a need to increase transmitter powers. This is considered further in Annex E.

3.6.4 Summary

In most countries that we are aware of, frequencies are licensed to the multiplex operators, although in some cases it is unclear or the frequencies may be licensed to the transmission network operator. We are not aware of any country other than Greece where the frequencies are licensed directly to the content providers.

Typically, a national DTT coverage plan is evolved, based on existing analogue conditions and the GE-06 process. This will typically provide 5-7 national coverage multiplexes. One or more of these multiplexes is typically reserved for the national public service broadcaster (e.g. BBC, France Television, RTE) and others may be obliged to carry existing free to air analogue services. The remainder of the multiplexes may be made available by auction or comparative selection, with more or less restrictive obligations

Although it may be that the two processes are equivalent in most ways (Greece has determined a frequency plan for each multiplex and by assigning frequencies to the content providers is effectively dictating the composition of multiplexes) the result may be inflexible, as it may be difficult to redistribute content channels between multiplexes over time to achieve the best spectrum efficiency.

On the other hand, such redistribution (e.g. as in the UK to release one of the 6 multiplexes for DVB-T2) can involve complex negotiation between all parties and the regulator. It is our view that this issue should be explicitly examined from regulatory, legal and commercial viewpoints.

4 DEVELOPMENTS OUTSIDE EUROPE

Interest in the use of former UHF TV spectrum for other applications extends beyond Europe; in particular there have been a number of auctions of spectrum in the 700 MHz range in the USA. The history of these auctions is helpful in illustrating how the value of this spectrum has increased in recent years as demand for broadband mobile services has grown.

A number of spectrum auctions covering the 700 MHz band have been held by the US Federal Communications Commission (FCC) over the last decade. The first auctions were held in 2002 and attracted only modest bids, but the most recent auction in 2008 yielded almost $20 Billion in total. In part the difference reflects the changing status of the band – the early auctions were held several years before the planned cessation of analogue broadcasting in the spectrum, which meant that bidders would either have to buy out the incumbent broadcasters or restrict their services to areas where the frequencies were not being used for broadcasting (typically covering up to 60% of the population) However a bigger factor is probably the emergence in the last two years of a consensus on the future use of this spectrum for mobile applications, in particular the decision at the 2007 World Radio Conference (WRC-07) to identify the frequencies above 698 MHz for future IMT services in ITU Region 2 (the Americas).

The figure below shows the former UHF spectrum released for non-broadcast applications in the USA since 2002.

Figure 4.1 USA 700 MHz spectrum

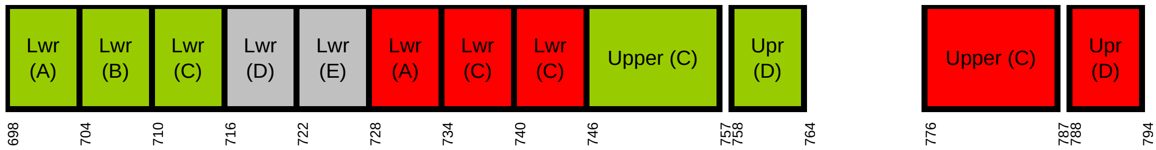


Table 4.1 summarises the outcomes of the auctions of this spectrum. It is clear from these auction results that the value of the former broadcast spectrum had increased significantly by 2008. This value increase is also illustrated by the fact that one of the buyers of the Lower C block spectrum in 2002, Aloha Partners, re-sold their acquisition to AT&T in 2007 for $2.5Bn, having originally acquired the spectrum for just $15M.

The amounts paid for 700 MHz spectrum are substantially higher than the amounts paid in European countries recently for spectrum in the 2.6 GHz band, confirming that bidders place a high premium on the coverage benefits provided at sub – 1 GHz spectrum. The availability of new spectrum below 1 GHz is also attractive in terms of facilitating migration from GSM to IMT / LTE technology, since there is insufficient spectrum in the existing 900 MHz band to support multiple operators and accommodate the wider bandwidths required by LTE whilst continuing to support GSM subscribers.

Table 4.1 Auctions of 700 MHz spectrum in the US

Year	Block	Spectrum	Amount $	Buyer(s)	Coverage	$/MHz/pop
2002	Lower A	2 x 6 MHz	Not sold			
2002	Lower B	2 x 6 MHz	Not sold			
2002	Lower C	2x6 MHz	84M	Various	201M	0.03
2002	Lower D	6 MHz	4.1M	Aloha Partners	47M	0.02
2003	Lower C	2 x 6 MHz	18.8M	Various	55M	0.03
2003	Lower D	6 MHz	38M	Qualcomm	237M	0.03
2008	Lower A	2 x 6 MHz	3,960M	Various	300M	1.10
2008	Lower B	2 x 6 MHz	9,149M	Various	300M	2.54
2008	Upper C	2 x 11 MHz	4,747M	Verizon	300M	0.72
2008	Upper D	2 x 6 MHz	Not sold			
2008	Lower E	6 MHz	1,267M	Frontier, Qualcomm	300M	0.70

5 IMPACT OF RELEASING DIGITAL DIVIDEND SPECTRUM ON CURRENT DIGITAL TV TRANSITION PLAN IN GREECE

5.1 Overview of current plan

The transition from analogue to digital TV in Greece commenced on 1st November 2008 and is scheduled to complete in November 2012 with the closure of the remaining analogue services. During the transition phase, up to eight digital multiplexes will be delivered from 23 former analogue transmission sites[26], using some or all of the frequencies previously used for analogue transmission at those sites. Upon completion of switchover, there will be 158 main digital transmission sites, grouped into 11 "broader coverage areas" (ΕΠΨΕs), which have been derived from the original 45 coverage areas that were defined for analogue television. Each of these ΕΠΨΕs contains 1, 2 or 3 single frequency DTT networks (SFNs), all of which relay the same content channels within that ΕΠΨΕ.

Currently the plan envisages fixed rooftop reception in outlying areas of Greece and outdoor, portable reception in the most populous areas. These reception modes are identified as RPC1 and RPC2 respectively in the GE-06 plan.

The Greek television market currently comprises national, regional and local stations. There are four national stations operated by the public service broadcaster ERT and post-switchover there will be eight national private stations. Regional and local stations are all privately operated and the number varies by region, with up to nine officially licensed regional and local stations in some areas according to the relevant legislation. In addition to these free-to-air services there are also two national pay-TV stations. All of the national and most of the regional analogue stations will be entitled to capacity on the digital networks once the switchover is complete. Currently there is no legal provision for local digital stations, but this may change in the future. In many areas there are also currently a substantial number of unlicensed analogue stations; however these will not be entitled to capacity on the digital networks.

5.2 Requirement for digital multiplexes post-switchover

As a minimum, the post-switchover digital plan must be able to support the existing national ERT and licensed private national stations plus the number of licences allocated per geographical map area as shown in the three Decisions (15587, 60472, 3249/139). In addition, it has been decided that ERT shall operate a further two multiplexes, one exclusively for additional ERT stations and another to be shared between ERT services and the two existing analogue pay-TV stations. It

[26] 20 sites will transmit 7 multiplexes, 2 sites will transmit 8 multiplexes and 1 will transmit 6 mutiplexes.

has also been decided that a separate multiplex will be licensed for the provision of a mobile TV service based on the DVB Handheld (DVB-H) standard. The total number of multiplexes required to support national TV stations will therefore be six, namely:

- one to support the existing four national ERT stations
- two to support the eight national private stations
- one to support the existing pilot digital ERT programmes
- one to support new ERT stations and the two existing pay-TV services
- one to support mobile TV

In addition, multiplexes will also be required to support regional stations, however the number of these will vary by region, depending on the number of officially licensed analogue stations in each region.

5.3 Number of licences defined in the Decisions 15587, 60472 and 3249/139

Frequencies for private analogue television stations were originally defined in 1997, in the Common Ministerial Decision (CMD) 15587. This document defined each main transmitter site and the frequencies that were to be used by the private national, regional and local stations at those sites. A total of 42 coverage regions were defined in this Decision and a specific number of regional licences allocated to each region. An amendment was issued in 1998 (CMD 60472) which increased the number of regions to 44. A further amendment in 2004 increased the number of regions to 45. However, the frequency plan defined in these Decisions has never been implemented. Instead, the broadcasters were required to submit declarations stating which frequencies they were using on each transmission site.

To estimate the requirement for regional multiplexes in each area, we have analysed the number of licences in each analogue coverage region according to the above Decisions, and used this data to determine the number of multiplexes that would be required in each digital coverage region (ΕΠΨΕ) to support regional stations. The ΕΠΨΕ corresponding to particular analogue coverage regions is based on data provided by EETT and reproduced in Table 5.1 below. The highlighted rows show the maximum number of licences in each ΕΠΨΕ.

Table 5.1 Number of regional licences per analogue coverage region and corresponding digital coverage regions (ΕΠΨΕs) (source: EETT)

Broader Coverage Map according Draft Digital Plan	Coverage Map according Decisions 15587, 60472, 3249/139	Number of Licenses per Coverage Map according Decisions 15587, 60472, 3249/139 for regional and local stations	Number of regional and local licences according to the Declarations
ΕΠΨΕ 1	21	9	5
	22	2	5
	32	2	2
	43	1	0
ΕΠΨΕ 2	7	5	10
	8	4	3
	9	2	2
	10	1	4
	11	2	3
	12	3	0
	13	4	2
	14	3	2
	15	1	3
	15α	2	3
ΕΠΨΕ 3	1	2	3
	2	2	2
	3	2	1
	4	1	2
	5	2	5
	6	2	5
ΕΠΨΕ 4	16	4	6
	37	4	1
	38	2	2

Broader Coverage Map according Draft Digital Plan	Coverage Map according Decisions 15587, 60472, 3249/139	Number of Licenses per Coverage Map according Decisions 15587, 60472, 3249/139 for regional and local stations	Number of regional and local licences according to the Declarations
ΕΠΨΕ 5	38α	2	2
	39	3	2
ΕΠΨΕ 6	17	2	0
	18	2	1
	19	5	3
	20	2	0
	31	2	2
ΕΠΨΕ 7	22	2	5
	23	2	2
	24	1	2
	25	2	3
	28	3	3
ΕΠΨΕ 8	23	2	2
	26	1	1
	27	1	1
	29	1	0
	30	2	1
	31	2	2
ΕΠΨΕ 9	41	4	3
	42	4	13
ΕΠΨΕ 10	40	5	6
ΕΠΨΕ 11	33	2	3
	34	5	2
	35	3	2
	36	1	2

5.4 Post-switchover frequency plan

The post-switchover frequency plan is defined in a document prepared by the National Technical University of Athens[27] and provides for between 8 and 12 frequencies in each of the 23 defined SFNs serving the 11 broader coverage areas (ΕΠΨΕs), which are defined as follows:

Table 5.2 Coverage areas and SFNs in post-switchover digital plan

ΕΠΨΕ No	SFN No	Area served	Frequencies available
1	1	Western Greece, Epiros, Northern Eptanisa	12
1	2		12
2	1	Thessaloniki and Western Macedonia	12
2	2		12
3	1	Eastern Macedonia and Thraki	12
3	2		12
3	3		12
4	1	Thessalia	12
4	2		12
5	1	Boreio Aigaio, Samos-Ikaria	10
5	2		10
6	1	Eastern Central, Evrytania	12
7	1	Western Peloponnese,	12
7	2	Ionian Islands	12
7	3		12
8	1	Eastern Peloponnese,	12
8	2	Corinth	12
9	1	Attica, Cyclades	12
9	2		12

[27] see presentation "Long term frequency plan for digital television", Professor: C. Kapsalis, National Technical University Of Athens Laboratory of Radio and Communication

ΕΠΨΕ No	SFN No	Area served	Frequencies available
10	1	Dodecanese, Kastelorizo	12
10	2		8
11	1	Crete	12
11	2		12

5.5 Ability of digital channels to support existing national, regional and local stations

To determine how many existing analogue stations are likely to be required in each of the digital coverage areas (ΕΠΨΕs), we have analysed the licences assigned to each analogue coverage area in Decision 15587 and its subsequent amendments, as presented in

Table **5.1** above. In each ΕΠΨΕ, we have assumed that the number of regional stations required corresponds to the highest number of regional stations in any of the analogue coverage areas corresponding to that ΕΠΨΕ. For example, ΕΠΨΕ 1 includes analogue coverage areas 21, 22, 32 and 43, which have 9, 2, 2 and 1 number of licences to be given respectively. The number of regional digital stations assumed for ΕΠΨΕ 1 is therefore the highest of these four values, i.e. 9, and this will ensure that all citizens still have access to the same number of licences as they did previously.

The following table shows the number of regional digital stations in required in each of the 11 ΕΠΨΕs, based on the above analysis, and the corresponding total number of multiplexes required in each ΕΠΨΕ. The number in brackets is the maximum number of currently declared broadcast stations in each ΕΠΨΕ. We have assumed each ΕΠΨΕ will require six national multiplexes and that the capacity of each multiplex is four TV stations.

Table 5.3 Estimation of total no of multiplexes required in each digital coverage area (ΕΠΨΕ), based on analogue stations identified in Decision 15587 and amendments

ΕΠΨΕ	Analogue coverage map areas	Max no of regional or local licences	Regional mutliplexes required	Total multiplexes required
1	21,22,32,43	9 (5)	2.25	8.25
2	7,8,9,10,11,12,13,14,15,15α	5 (10)	1.25	7.25
3	1,2,3,4,5,6	2 (5)	0.5	6.5
4	16	4 (6)	1	7
5	37,38,38α,39	4 (2)	1	7
6	17,18,19,20,31	5 (3)	1.25	7.25
7	22,23,24,25,28	3 (5)	0.75	6.75
8	23,26,27,29,30,31	2 (2)	0.5	6.5
9	41,42	4 (13)	1	7
10	40	5 (6)	1.25	7.25
11	33,34,35,36	5 (3)	1.25	7.25

For each ΕΠΨΕ and SFN , we determined the number of frequencies that would be available within the current national digital plan, if the 790 – 862 MHz band were to be removed. We then compared this with the number of multiplexes required in each ΕΠΨΕ (from Table 5.3 above) to work out the number of additional TV stations that could be accommodated in each ΕΠΨΕ if the digital dividend frequencies were removed. The shaded rows show the SFN in the ΕΠΨΕ with the minimum spare capacity available.

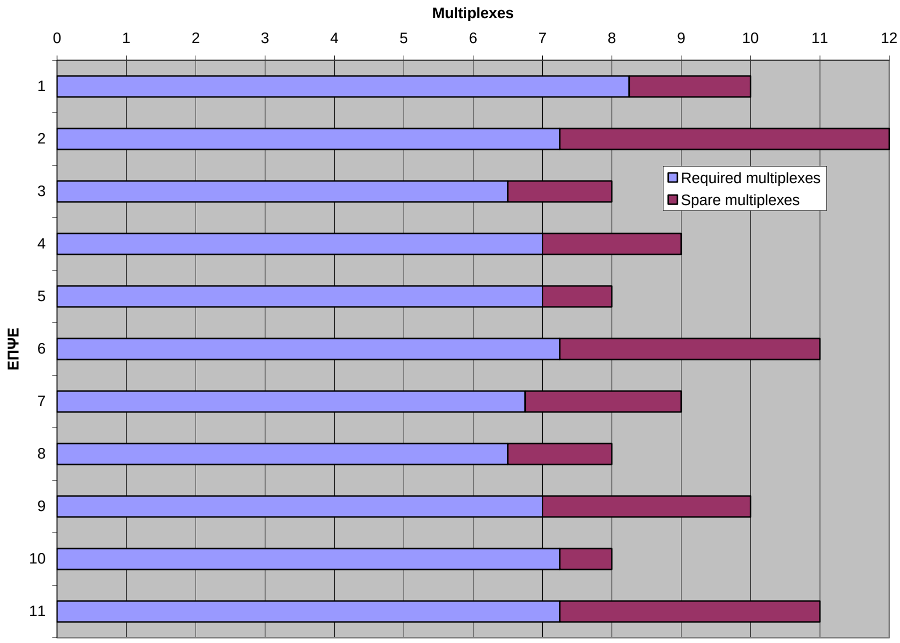
It can be seen that the minimum number of additional TV stations that can be accommodated is 3, in ΕΠΨΕ 10.

Table 5.4 Impact of removing channels 61 – 69 on the number of additional TV stations that can be accommodated in each ΕΠΨΕ

ΕΠΨΕ	SFN	Frequencies available without ch 61 - 69	Minimum multiplexes required	Spare Multiplex capacity	Additional TV stn capacity
1	1	10	8.25	1.75	7
1	2	12	8.25	3.75	15
2	1	12	7.25	4.75	19
2	2	12	7.25	4.75	19
3	1	11	6.5	4.5	18
3	2	11	6.5	4.5	18
3	3	8	6.5	1.5	6
4	1	10	7	3	12
4	2	9	7	2	8
5	1	9	7	2	8
5	2	8	7	1	4
6	1	11	7.25	3.75	15
7	1	12	6.75	5.25	21
7	2	11	6.75	4.25	17
7	3	9	6.75	2.25	9
8	1	12	6.5	5.5	22
8	2	8	6.5	1.5	6
9	1	10	7	3	12
9	2	12	7	5	20
10	1	10	7.25	2.75	11
10	2	8	7.25	0.75	3
11	1	11	7.25	3.75	15
11	2	11	7.25	3.75	15

The number of required multiplexes and spare multiplexes available in each ΕΠΨΕ is shown below:

Figure 5.1 Number of required multiplexes and spare multiplex capacity available in each ΕΠΨΕ, assuming channels 61 – 69 are removed from the digital plan



5.6 Other options for spectrum release

There could be benefit in releasing additional spectrum on a nationwide basis below 790 MHz, e.g. for use by PMSE services or to provide rural broadband wireless access. There may also be scope to replace the existing military use of channels 67 – 69 with similar bandwidth below 790 MHz, to reduce the impact on the digital dividend. To be most useful, such spectrum should preferably comprise two or more adjacent TV channels, to minimise fragmentation and the need for guard spectrum. We attempted to identify the largest contiguous block of spectrum that could be removed (in addition to the proposed harmonised band above 790 MHz) without compromising the ability to deliver eight multiplexes in each region, using a spreadsheet to compare the number of multiplexes available with and without the removed spectrum (see figure below – the channels selected for removal are highlighted in blue).

Figure 5.1 Spreadsheet of number of multiplexes

ΕΠΨΕ	SFN	Impact	Available channels before	Available channels after	B3	21	22	23	24	25	26	27	28	29	30	31	32
1	1		10	8			1	1	1								
1	2		12	11		1				1		1					
2	1		12	9				1		1							
2	2		12	10					1		1	1					
3	1		11	8					1								
3	2		11	11				1			1						
3	3		8	8			1			1		1					
4	1		10	8			1										
4	2		9	9		1											
5	1		9	9	1	1				1							
5	2	yes	8	7	1							1					
6	1		11	10				1	1	1	1						
7	1		12	9						1							
7	2		11	11		1					1						
7	3		9	8			1		1								
8	1		12	11				1	1								
8	2		8	8		1	1			1							
9	1		10	9			1	1	1		1	1					
9	2		12	9													
10	1		10	9	1	1			1								
10	2		8	8	1					1		1					
11	1		11	10		1			1	1							
11	2		11	11	1							1					

ΕΠΨΕ	SFN	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
1	1	1				1						1								1					1				
1	2		1					1		1				1				1			1	1						1	
2	1			1								1	1		1				1						1			1	
2	2							1	1	1						1				1	1			1					
3	1	1		1	1							1				1											1	1	
3	2		1			1	1		1								1	1			1	1							1
3	3							1		1										1			1		1				
4	1			1			1		1		1					1					1	1							
4	2				1	1				1			1							1			1				1		1
5	1	1						1			1				1							1			1				
5	2		1	1	1		1						1																
6	1	1		1		1												1						1		1			
7	1		1								1		1		1	1	1	1				1							
7	2			1	1		1		1					1									1			1		1	1
7	3	1				1															1			1	1		1		
8	1			1		1		1		1	1		1									1				1	1		
8	2								1					1	1									1	1				
9	1																1				1		1					1	
9	2		1		1		1					1				1		1	1	1									1
10	1							1			1								1		1				1			1	
10	2			1						1								1		1		1							
11	1					1	1	1		1								1							1	1			
11	2	1	1	1	1								1		1							1	1					1	

.

Our analysis revealed that the contiguous block of spectrum comprising channels 28 – 32 inclusive (526 – 566 MHz) could be released for other uses in addition to the harmonised European digital dividend spectrum whist still meeting the required number of multiplexes for national and regional stations in each ΕΠΨΕ, with the exception that there is a one station shortfall in ΕΠΨΕ 1. However, we would question whether the requirement for 9 regional stations in this ΕΠΨΕ is valid, as the maximum number of regional stations according to the broadcasters' declarations is only 5. In any case, it should be possible to recover the shortfall by using spare frequencies from the GE-06 plan (see next section) or by redeploying the unused multiplex frequency from the second SFN in ΕΠΨΕ1.

It should be noted that release of a further contiguous block of spectrum is of lesser importance to the release of the digital dividend as the potential to harmonise further spectrum across Europe is likely to be very difficult.

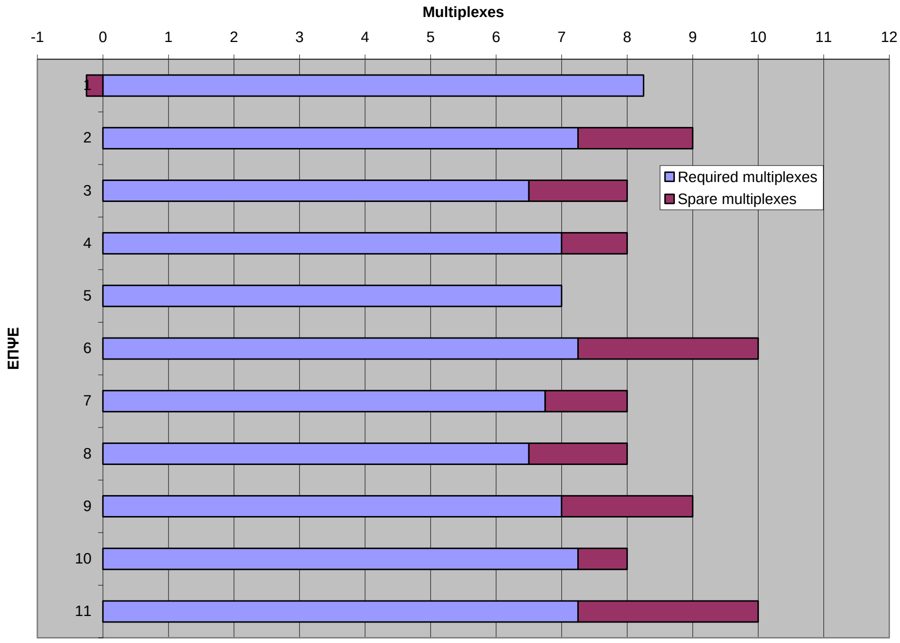
Table 5.5 Impact of removing channels 61 – 69 and 28 – 32 on the number of additional TV stations that can be accommodated in each ΕΠΨΕ

ΕΠΨΕ	SFN	Frequencies available without channels 61–69 and 28 - 32	Minimum multiplexes required	Spare Multiplex capacity	Additional TV stn capacity
1	1	8	8.25	-0.25	-1
1	2	11	8.25	1.75	11
2	1	9	7.25	1.75	7
2	2	10	7.25	2.75	11
3	1	8	6.5	1.5	6
3	2	11	6.5	4.5	18
3	3	8	6.5	1.5	6

ΕΠΨΕ	SFN	Frequencies available without channels 61–69 and 28 - 32	Minimum multiplexes required	Spare Multiplex capacity	Additional TV stn capacity
4	1	8	7	1	4
4	2	9	7	2	8
5	1	9	7	2	8
5	2	7	7	0	0
6	1	10	7.25	2.75	11
7	1	9	6.75	2.25	9
7	2	11	6.75	4.25	17
7	3	8	6.75	1.25	5
8	1	11	6.5	4.5	18
8	2	8	6.5	1.5	6
9	1	9	7	2	8
9	2	9	7	2	8
10	1	9	7.25	1.75	7
10	2	8	7.25	0.75	3
11	1	10	7.25	2.75	11
11	2	11	7.25	3.75	15

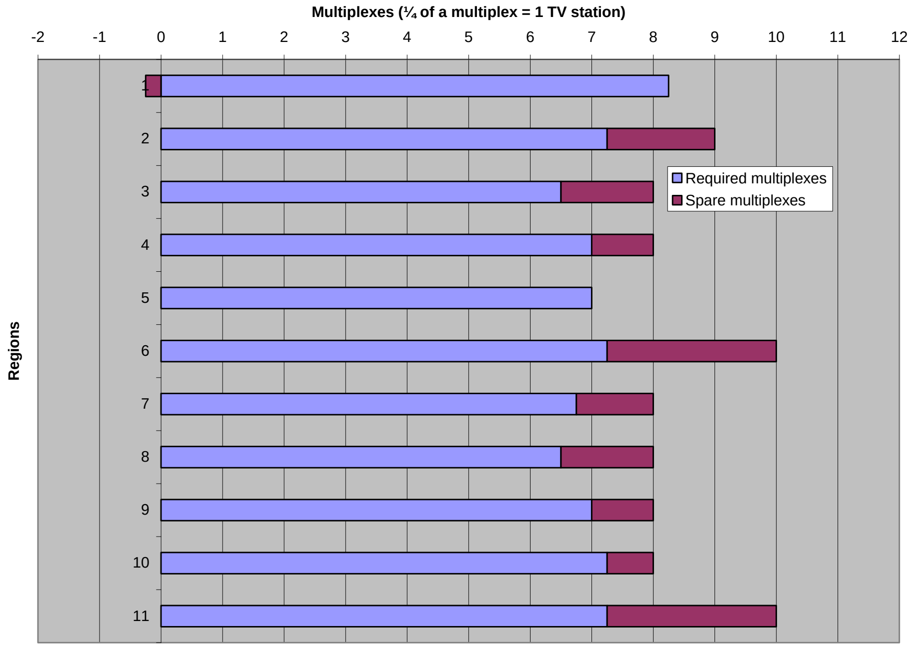
The number of required multiplexes and spare multiplexes available in each ΕΠΨΕ is shown below:

Figure 5.2 Number of required multiplexes and spare multiplex capacity available in each ΕΠΨΕ, assuming channels 61 – 69 and 28 – 32 are removed from the digital plan



In the event that channel 60 cannot be used due to adjacent channel interference constraints, this does not create any further shortfalls in the number of multiplexes per ΕΠΨΕ.

Figure 5.3 Number of required multiplexes and spare multiplex capacity available in each ΕΠΨΕ, assuming channels 60 – 69 and 28 – 32 are removed from the digital plan



5.7 Availability of "spare" frequencies from the GE-06 plan

The current digital frequency map for Greece does not use all of the frequencies allotted to Greece in the GE-06 plan. The existence of additional frequencies in some areas provides additional flexibility to provide additional TV services in those areas that may be constrained by the removal of digital dividend frequencies, or to make digital dividend frequencies available more widely within Greece if neighbouring countries do not decide to adopt the dividend. The following table shows the number of these "unused" frequencies in each of the 34 allotment areas, along with the corresponding ΕΠΨΕ area in which the frequency could be used.

Table 5.6 Unused Greek allotment frequencies in the GE-06 plan

Allotment No	Allotment Name	Corresponding ΕΠΨΕ No(s)	Unused allotments (channel nos)	Spare UHF frequencies outside DD
1	Evros	3	7	0
2	Plaka	3	10,27,33	2
3	Thassos	3	6,47	1
4	Paggaio	3	7,32,35,63	1
5	Thessaloniki	2,3,4	5,62	0
6	Xalkidiki	2,3	11,25	1
7	Florina	2	7,8,34,49,61	2
8	Metaksas	2,4	6	0
9	Ioninina	1	10,30,32,34,54	2
10	Thesprotia	1	9,66	0
11	Kerkyra	1	9,54	1
12	Larissa	4	7	0
13	Akarnanika	1	6,32,46,64	1
14	Bolos	4	6	0
15	Lamia	6	10.32,60,64	1
16	Karpenisi	6	5,29,36,47,61,62	3
17	Ainos	7	8	0
18	Patra	7	7,22,31,53	2
19	Korinthos	8	9,38,43,51,59,64	4

Allotment No	Allotment Name	Corresponding ΕΠΨΕ No(s)	Unused allotments (channel nos)	Spare UHF frequencies outside DD
20	Attiki	9	5,11	0
21	Athina	9	7	0
22	Pyrgos	7	5,11	0
23	Tripoli	8	10,50,60,62	2
24	Nafplio	8	6,33	1
25	Kalamata	7	6,29,44	1
26	Sparti	8	11,27,30,33,36,52,57	5
27	West Crete	11	7	0
28	Central Crete	11	10	0
29	East Crete	11	31,35,38,46,54	4
30	Dodekanisa	10		0
31	Kyklades	31	8,32	0
32	Samos	32	67	0
33	Lesvos	5		0
34	Kastellorizo	10		0

The area covered by ΕΠΨΕ 1 comprises allotments 9, 10, 11 and 13. Allotments 9 and 11 both have channel 54 available and allotment 13 has channel 46. It is likely that either of these channels could be deployed to make up the single channel shortfall in ΕΠΨΕ 1, SFN 1, depending on the extent to which these channels are used in other nearby ΕΠΨΕs. The feasibility of deploying these “spare” GE-06 channels is discussed further in section 5.10.3.

5.8 Local broadcasting

The current Greek digital TV frequency plan does not cater for local stations, but it may be necessary to do so in the future. In general, there are two approaches to the provision of local broadcasting using the DVB-T standard. The first and simplest approach is simply to reserve some capacity on one multiplex within the relevant ΕΠΨΕ. This approach avoids the need for any further frequency planning, or the provision of new transmitter equipment, but has the disadvantage that the coverage of the new local service may be much larger than required.

The second approach is to provide a low-power transmitter specifically designed to target the local area concerned. While this approach avoids the ‘overspill’ problem, and does not reduce the capacity available on the main multiplex, there are some drawbacks, namely:

- A transmission site must be found that will allow the majority of homes targeted to use their existing aerials
- A 'spare' frequency must be identified for the new service
- It is unlikely that a local coverage multiplex will find sufficient programme content to make full use of the capacity
- Arrangements will be needed for the appropriate cross carriage of service information (SI) on both local and regional multiplexes.

None of these drawbacks need be particularly severe, but the final approach may need careful consideration.

5.9 Availability of channels 67, 68 and 69 in Greece

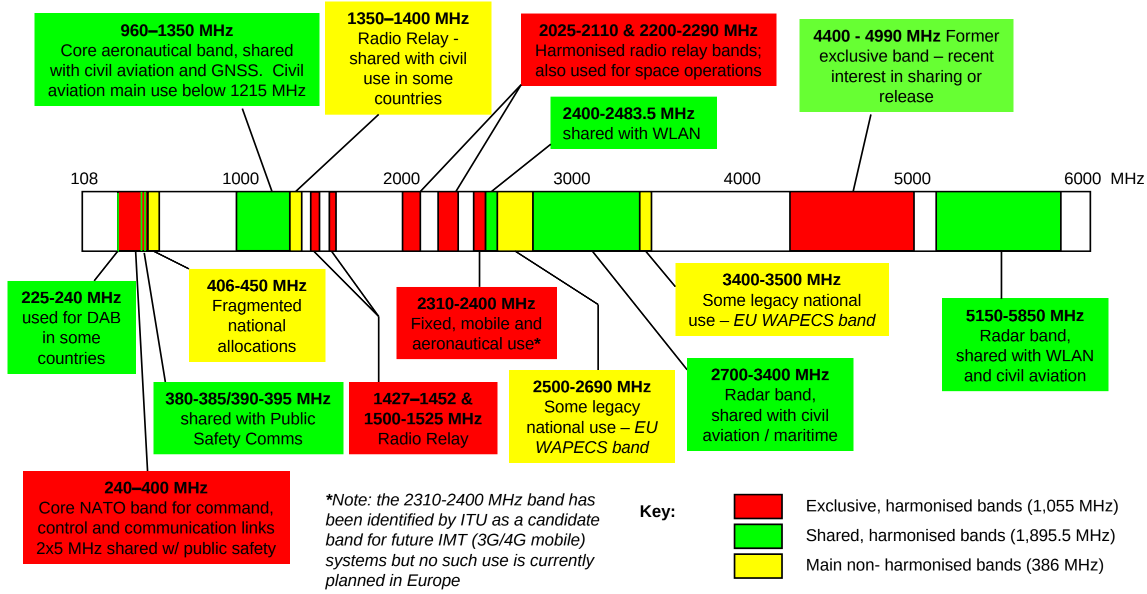
We understand the military are currently utilising channels 67 – 69 (838 – 862 MHz) in Greece. In the European Common Allocation (ECA) Online Database[28] the bands 870-876 and 915-921 MHz are identified as preferred bands for TRR (Tactical Radio Relay) for defence systems, in particular for cross-border operations. In countries where these bands are or will be in civil use according to ERC/ECC Decisions (e.g. for digital PMR/PAMR), shared use of the bands should be considered on a national basis. Other sub-bands within the tuning range 610-960 MHz may also be used on a national basis according to the national requirements.

Assuming the usage of the channels 67 – 69 in Greece is for TRR then there may be the potential to adopt the frequencies mentioned in the ECA. Another possible approach is to utilise the duplex gap (channel 65, 822 – 830 MHz) in the proposed FDD channelling arrangement for the 790 – 862 MHz spectrum. We assume that the current paired spectrum does not lie within the 470 – 838 MHz frequency range but is between 862 and 960 MHz. There will be a need to co-ordinate any military use with TV stations using adjacent channels, both in Greece and in neighbouring countries. In the case of 822 – 830 MHz there may be a need for additional sharing studies to ensure compatibility with cellular mobile services in the adjacent bands.

Finally, we note that a number of European countries have already migrated military systems from the 610 – 960 MHz bands to other bands that are harmonised within the European / NATO area. This is part of a wider trend within the international military community to harmonise spectrum use into certain "core" bands. The harmonised bands are shown in the figure below.

[28] See: http://apps.ero.dk/ECA/ecadetails.aspx?lstfreq=1012

Figure 5.4 Principal Military Frequency Bands in Europe[29]



5.10 Impact of migrating military use to frequencies below 790 MHz

We have considered two options for relocating military use of spectrum to below 790 MHz, namely:

i) relocation of the entire 24 MHz from channels 67 to 69 inclusive to a contiguous three-channel block below 790 MHz, and

ii) relocation of 8 MHz of the current military band to channel 65 (which is within the duplex gap for the proposed harmonised mobile band) and the remaining 16 MHz to a contiguous two-channel block below 790 MHz.

The impact of these two options on any potential digital dividend is described in the next two sections.

5.10.1 Impact of migrating all military use to below 790 MHz

Our analysis has identified that the smallest impact occurs when the military use is migrated to channels 57 – 59 inclusive. If only the harmonised digital dividend is required, removing channels 57 – 59 as well as channels 61 – 69 has the following impact on each ΕΠΨΕ in the digital plan. It can be seen that there remains ample spare capacity in each ΕΠΨΕ.

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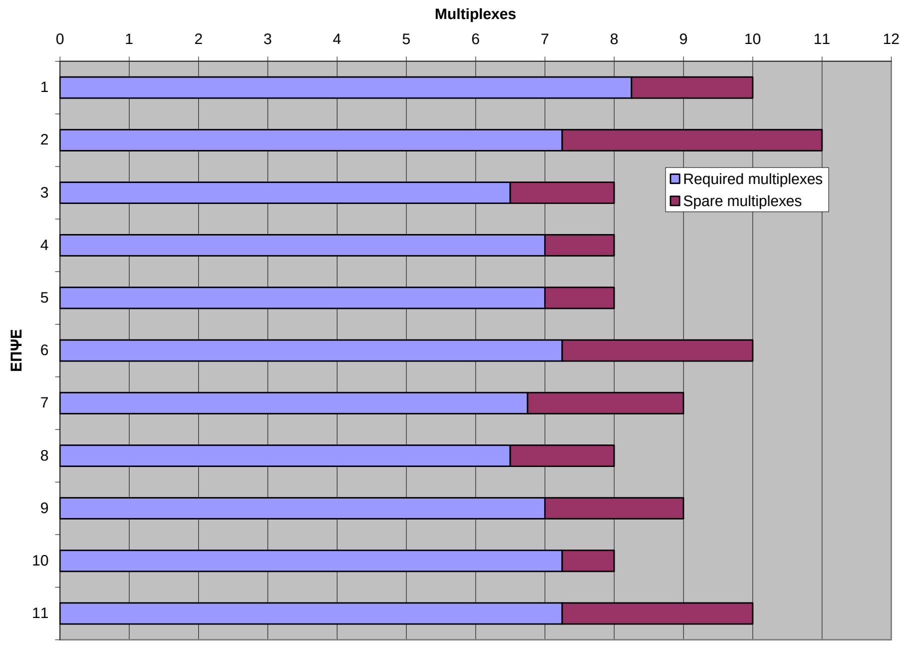
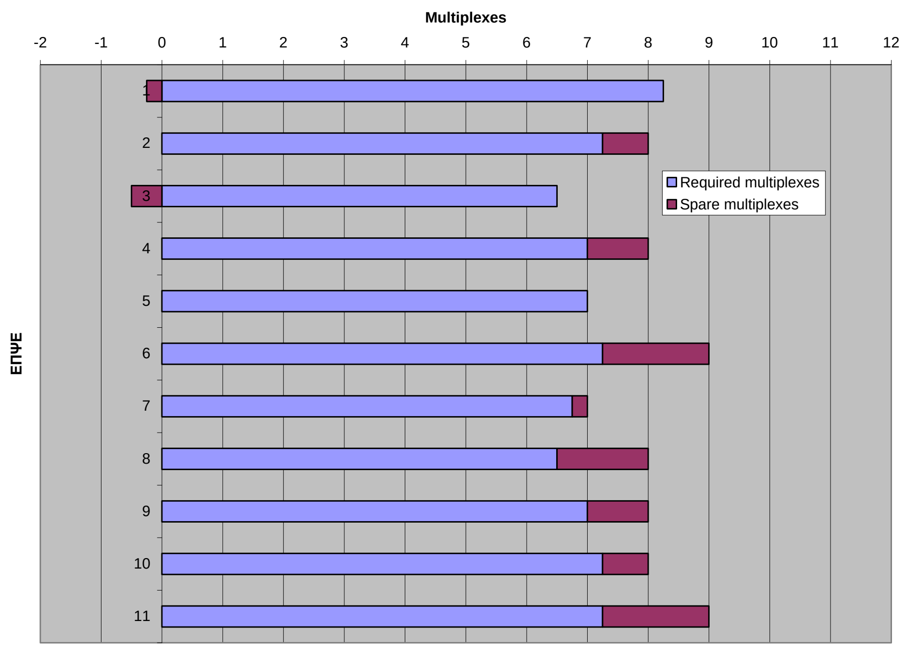
[29] source: "Optimising spectrum use in the public sector", J Burns, presentation to Cambridge Wireless Workshop, October 2008 (www.aegis-systems.co.uk/download/2007/CW_spectrum_v1.pdf)

Figure 5.5 Number of required multiplexes and spare multiplex capacity available in each ΕΠΨΕ, assuming channels 61 – 69 and 57 – 59 are removed from the digital plan



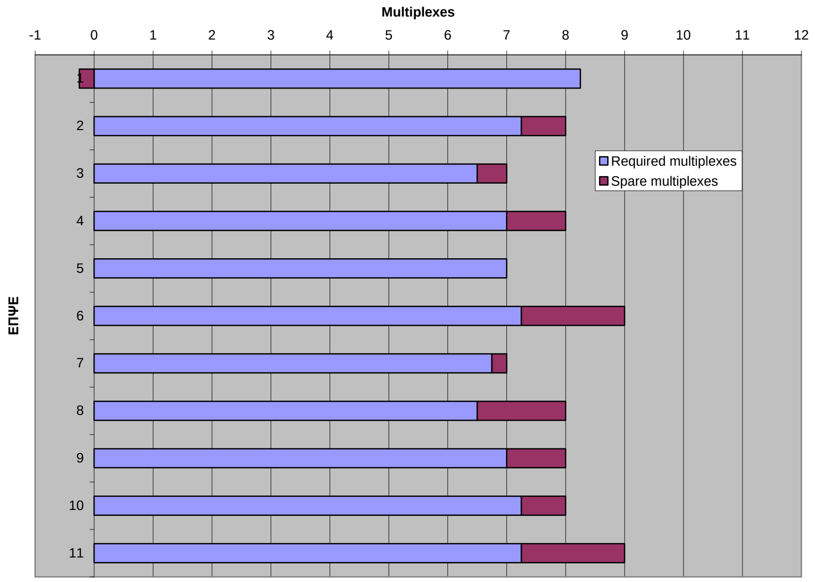
However, there is a greater impact if the additional digital dividend frequencies previously identified (channels 28 – 32) are also removed. As can be seen below, this results in a shortfall of frequencies in both ΕΠΨΕ 1 and ΕΠΨΕ 3. ΕΠΨΕ 3 is likely to be more of a problem than ΕΠΨΕ 1 as there are currently more declared analogue stations than are covered by the decisions, whereas in ΕΠΨΕ 1 the situation is the other way round.

Figure 5.6 Number of required multiplexes and spare multiplex capacity available in each ΕΠΨΕ, assuming channels 61 – 69, 57 – 59 and 28 – 32 are removed from the digital plan



The impact is reduced if only channels 28 – 31 are released – in this case only ΕΠΨΕ 1 is affected and as previously noted this is unlikely to be an irresolvable problem.

Figure 5.7 Number of required multiplexes and spare multiplex capacity available in each ΕΠΨΕ, assuming channels 61 – 69, 57 – 59 and 28 – 31 are removed from the digital plan



The impact can be further reduced by removing only three additional channels from the digital plan – in the following two examples channels 28 – 30 and 29 – 31 inclusive have been removed, in addition to channels 57 – 59 and 61 – 69:

Figure 5.8 Number of required multiplexes and spare multiplex capacity available in each ΕΠΨΕ, assuming channels 61 – 69, 57 – 59 and 28 – 30 are removed from the digital plan

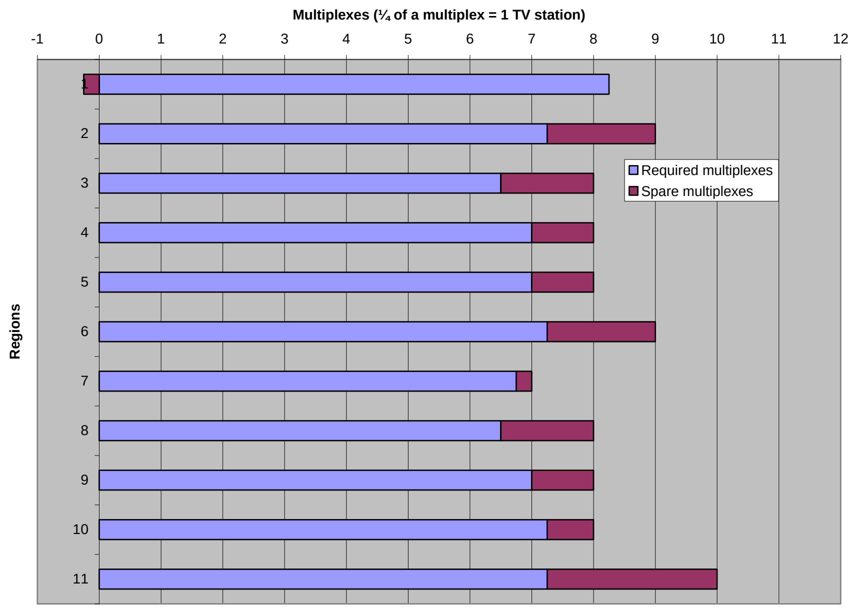
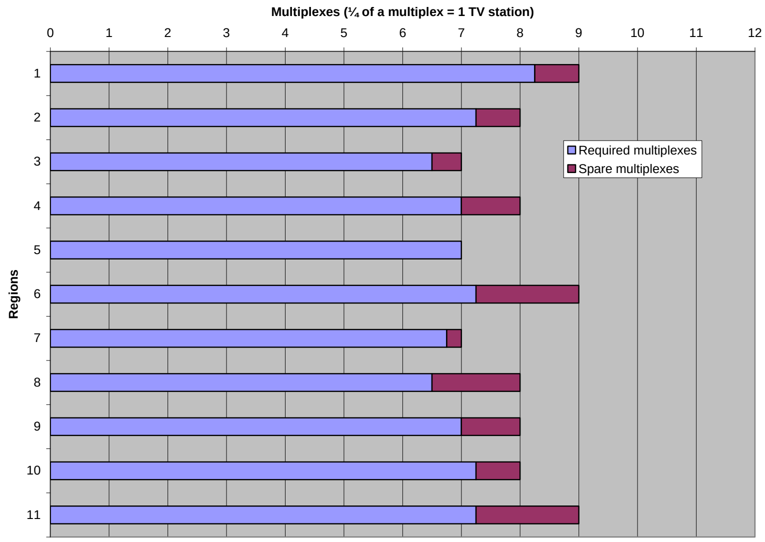


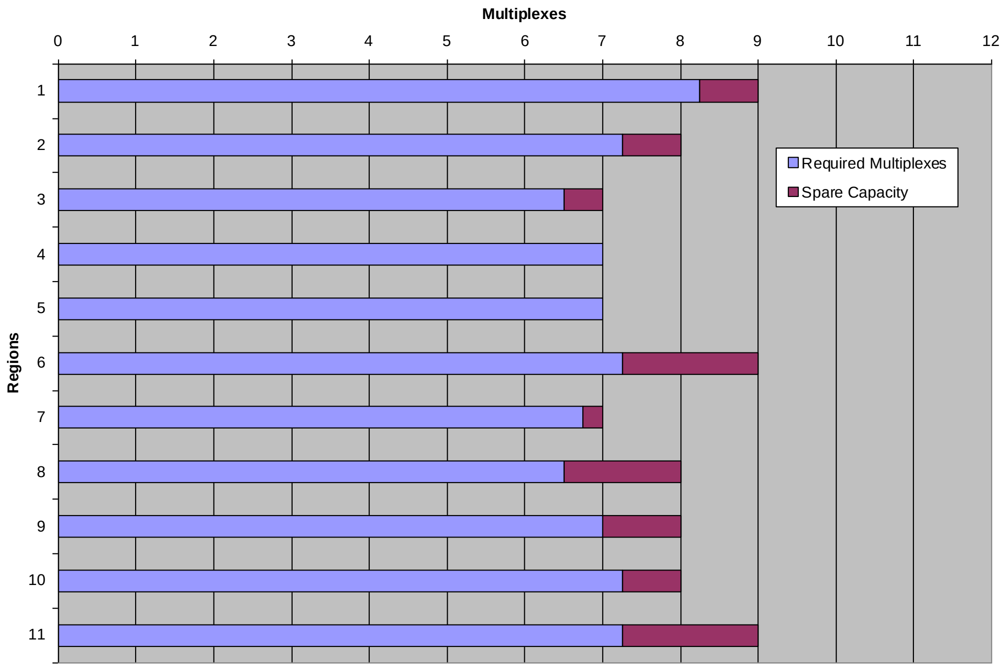
Figure 5.9 Number of required multiplexes and spare multiplex capacity available in each ΕΠΨΕ, assuming channels 61 – 69, 57 – 59 and 29 – 31 are removed



Note that if only channels 29 - 31are removed there is no longer any shortfall in ΕΠΨΕ 1 and there are sufficient multiplexes in all areas to meet the required number of regional stations according to the legislation.

The impact if channel 60 is required as a possible “guard band” between military use and the digital dividend and it can be seen that there are sufficient multiplexes.

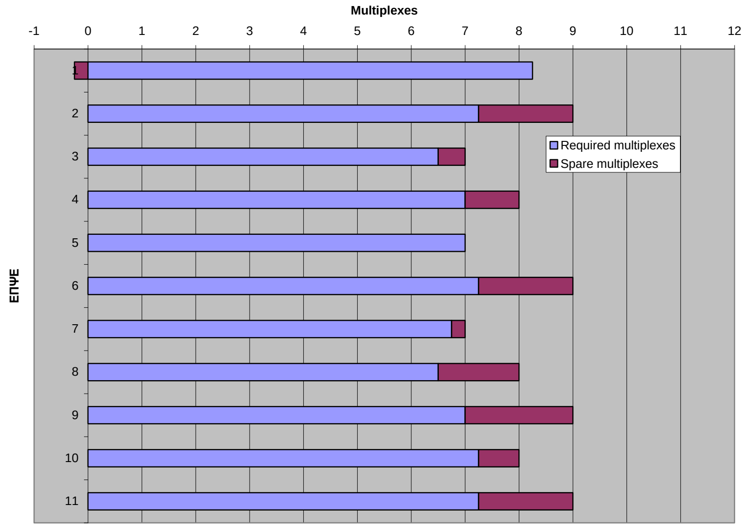
Figure 5.10 Number of required multiplexes and spare multiplex capacity available in each ΕΠΨΕ, assuming channels 60 – 69, 57 – 59 and 29 – 31 are removed



5.10.2 Impact of migrating 16 MHz of military use to below 790 MHz and retaining the other 8 MHz in channel 65 (the mobile duplex gap)

In this case it can be seen that only ΕΠΨΕ 1 is affected and as previously noted this is unlikely to be an irresolvable problem. This approach also has the advantage that it provides sufficient frequencies to accommodate all of the currently declared regional stations in the Athens area (there are 13 declared stations but only 4 "official" licences in the legislation.

Figure 5.10 Number of required multiplexes and spare multiplex capacity available in each ΕΠΨΕ, assuming channels 61 – 69, 57 – 58 and 28 – 32 are removed



5.10.3 Impact of releasing two paired blocks of spectrum for military use

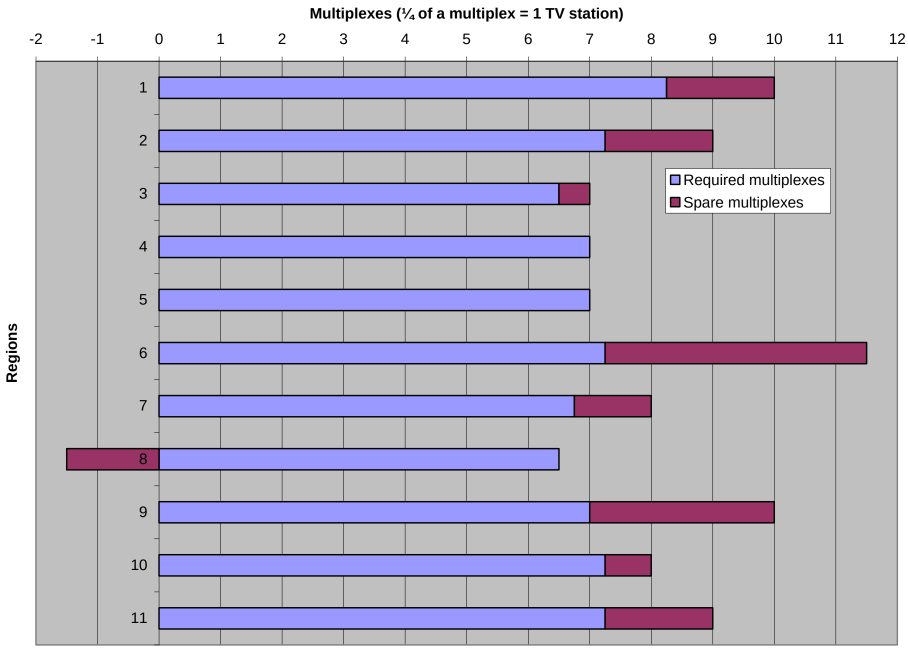
We were asked by EETT to consider two further specific options for military use, namely the release of either 2 x 24 MHz or 2 x 16 MHz, with a 28 MHz duplex spacing between the two blocks. We have assumed that both blocks would have to be in the range 610 – 790 MHz (to be within the military equipment tuning range and avoid impacting on the harmonised digital dividend band) and that the duplex gap could be increased to 32 MHz (to be compatible with the 8 MHz TV channel spacing). We have also assumed that no further digital dividend beyond channels 61-69 would be available.

5.10.3.1 Impact of releasing 2 x 24 MHz for military use

Our analysis indicates that the smallest impact on the broadcast plan arises if channels 38 – 40 and 44 – 46 are released. This results in a 2 multiplex shortfall in ΕΠΨΕ 8 on SFN 2, but there are spare frequencies available in SFN 1. Other parings either affect more than one ΕΠΨΕ or result in shortfalls that cannot be recovered by switching frequencies from another SFN.

The impact on each ΕΠΨΕ of this option is shown below.

Figure 5.11 Number of required multiplexes and spare multiplex capacity available in each ΕΠΨΕ, assuming channels 61 – 69, 38 - 40 and 45 - 47 are removed from the digital plan



5.10.3.2 Impact of releasing 2 x 16 MHz for military use

In this case all pairing options affect at least one ΕΠΨΕ but where only a single ΕΠΨΕ is affected there is at least one spare channel on another SFN within the ΕΠΨΕ that could be used. The following pairing options affect two or more ΕΠΨΕs and are therefore not recommended:

- channels 40 – 41 / 46 – 47
- channels 46 – 47 / 52 – 53
- channels 49-50 / 55-56
- channels 50 – 51 / 56-57

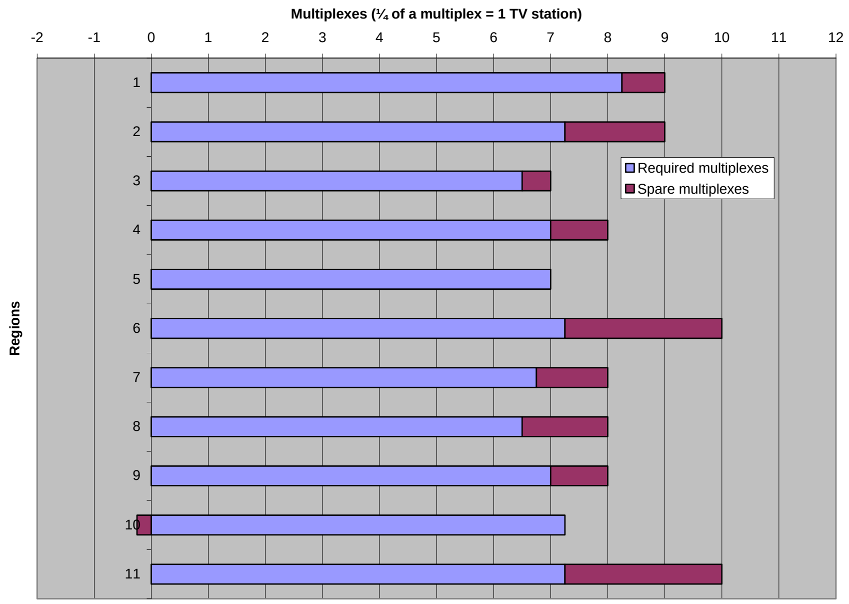
5.10.3.3 Impact of releasing 3 contiguous channels within the channel 51 – 54 range

Removal of any three contiguous channels in this range will result in a shortfall in ΕΠΨΕ 10. The smallest impact is achieved with channels 50 – 52 inclusive, as shown below.

Figure 5.12 Number of required multiplexes and spare multiplex capacity available in each ΕΠΨΕ, assuming channels 61 – 69 and 50 - 52 are removed from the digital plan

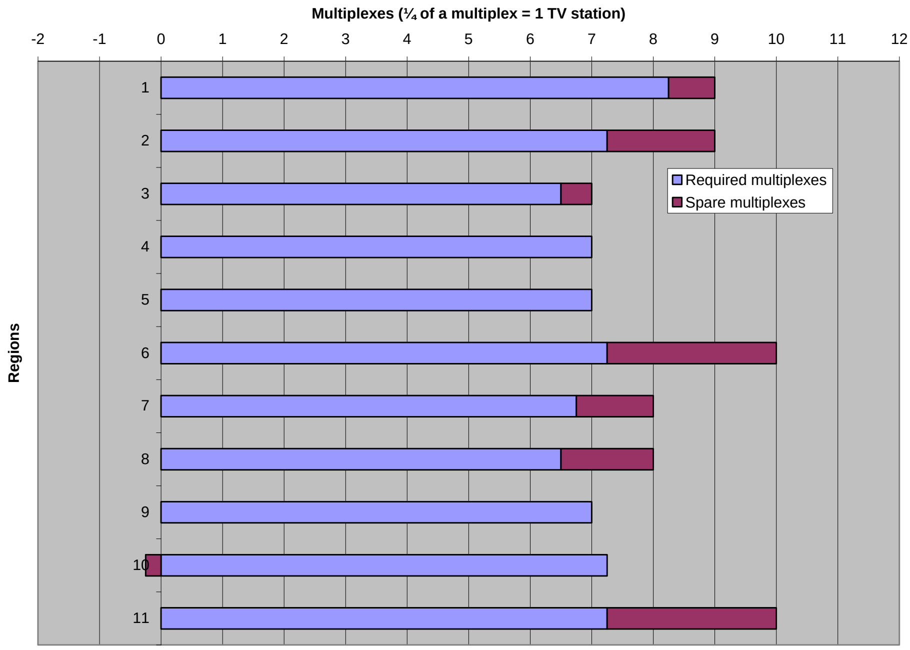
It is also possible to remove channels 30 – 32 inclusive without any further shortfalls, as shown below:

Figure 5.13 Number of required multiplexes and spare multiplex capacity available in each ΕΠΨΕ, assuming channels 61 – 69 , 50 - 52 and 30 – 32 are removed from the digital plan



Finally, if channel 60 is not available due to adjacent channel interference concerns, there are still no further shortfalls created although several multiplexes are left with no spare capacity:

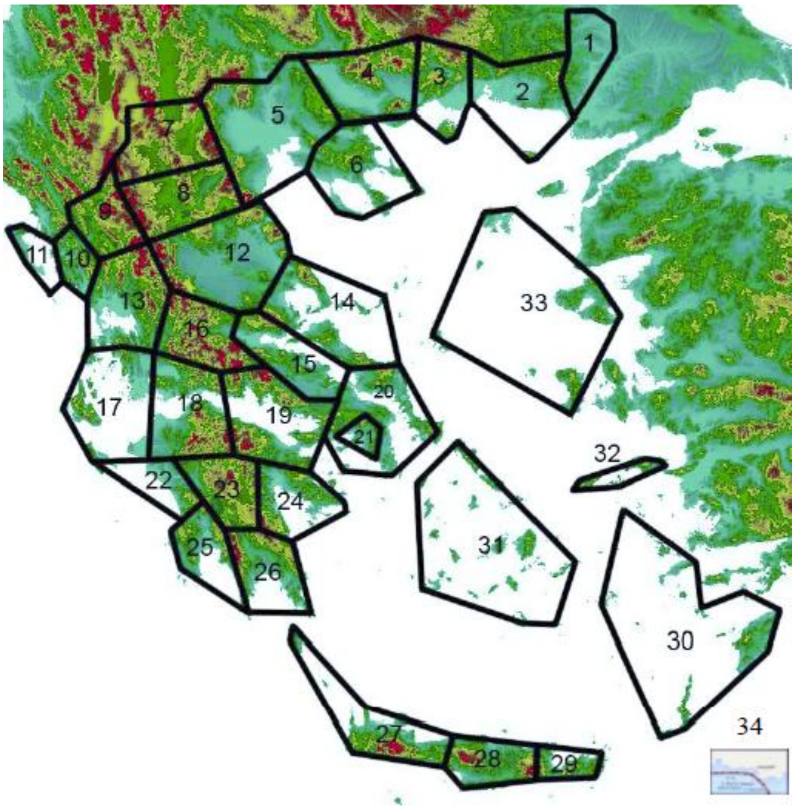
Figure 5.14: Number of required multiplexes and spare multiplex capacity available in each ΕΠΨΕ, assuming channels 60 – 69 , 50 - 52 and 30 – 32 are removed from the digital plan



5.11 Impact of using "spare" channels from the GE-06 plan to overcome channel shortfalls in particular ΕΠΨΕs

In several of the scenarios considered above there is a shortfall in the number of available multiplexes in one or more ΕΠΨΕs when all of the digital dividend and/or military frequencies are removed. In the worst case (channels 28-32, 57-59 and 61-69 removed – see figure 5.5), there is a shortfall in ΕΠΨΕ 1 and ΕΠΨΕ 3. One solution to this shortfall may be to use channels that have been allotted to Greece in the GE-06 plan but are not currently used in the digital frequency plan. These frequencies are listed by allotment area in table 5-6. The Greek allotment areas are shown in the figure below:

Figure 5.15 Greek GE-06 allotment areas



ΕΠΨΕ 1 corresponds to allotment areas 9, 10, 11 and 13. The following “spare” UHF channels are available in each of these allotment areas:

Table 5.7 Spare GE-06 frequencies in allotment areas corresponding to ΕΠΨΕ 1

Allotment No	Allotment Name	Spare channels
9	Ionina	34,54
10	Thesprotia	
11	Kerkyra	54
13	Akarnanika	46

Ideally we need to identify one of these frequencies that can be used throughout the ΕΠΨΕ without affecting its use elsewhere in Greece or neighbouring countries. As channel 54 is used in both allotments 9 and 11, this would appear to be an attractive option. However, this channel is also allotted to allotment areas 3,6, 8,18, 20, 27 and 29. In the current digital plan, the channel is used in allotments 3 (to serve ΕΠΨΕ 3), 8 (ΕΠΨΕ 4), 18 (ΕΠΨΕ 7), 20 (ΕΠΨΕ 9) and 27 (ΕΠΨΕ 11). Allotments 3, 20 and 27 are sufficiently far away not to be affected by use in ΕΠΨΕ 1, however there would be a conflict with use in allotments 3 (ΕΠΨΕ 3) 8 (ΕΠΨΕ 4) and 18 (ΕΠΨΕ 7).

Channel 46 is allotted to allotments 6 (ΕΠΨΕ 2), 22 ((ΕΠΨΕ 7), 24 (ΕΠΨΕ 8) 27 (ΕΠΨΕ 11), 29 (not used) and 30 (ΕΠΨΕ 5). All of these should be sufficiently distant to avoid any conflict; however it may be necessary to undertake bilateral co-ordination with neighbouring countries to facilitate use of this frequency throughout ΕΠΨΕ 1.

The optimum solution in this case however would be to use channel 34, which is already included in the digital plan for ΕΠΨΕ 1 but is assigned to SFN 2, which our analysis shows would have 10 multiplexes available with all these channels removed, whereas SFN 1 would have only 8. Since 9 are required to deliver all the regional stations in ΕΠΨΕ 1, transferring channel 34 from SFN 2 to SFN 1 would overcome the shortfall.

Similarly in ΕΠΨΕ 3 the shortfall only affects one of the three SFNs that are planned for that ΕΠΨΕ (SFN 1). Transferring one of the frequencies that are currently assigned to SFNs 2 or 3 would overcome the problem.

5.12 Provision of mobile digital TV within the post-switchover plan

Separate provision has been made for mobile digital TV under the Greek regulatory regime. Under the terms of Decision 3593 of 2007, frequencies currently used to transmit pay-TV services in Greece have been set aside for future provision of mobile TV based on the DVB-H standard. The intention is that at digital switchover the frequencies would be released to ERT who would then tender for provision of a mobile TV service using some of the frequencies. We have assumed that a single multiplex will be sufficient for the provision of a mobile TV service and have taken this into account in our estimation of the number of multiplexes required in each ΕΠΨΕ area in section 5.5 above.

We have compared the two frequencies currently used by the pay-TV services at each transmission site and have determined that at a number of sites neither of the frequencies are included in the current post-switchover digital plan. The affected sites include Ακαρνανικα, Δαμαστα, Θολοποταμι, Κερκυρα (Παντοκρατορασ), Πλακα, Σπαρτη (Αναβρυτη) and Υμηττοσ.

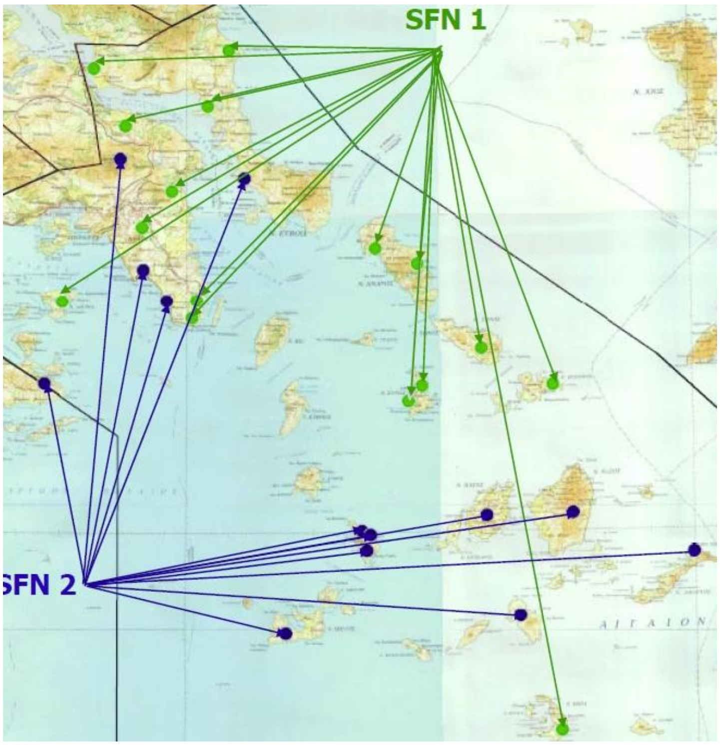
5.13 Potential to increase capacity by adopting a single SFN per ΕΠΨΕ

The current post-switchover digital plan defines up to 3 separate SFN in each broadcasting area (ΕΠΨΕ). Such an arrangement would normally be adopted where (i) different (i.e. locally-targeted) programme content was to be transmitted on the different SFNs or (ii) if the ΕΠΨΕ area was so large as to make it technically impossible to provide coverage in a single SFN due to guard-interval restrictions. In either case, one would expect that each SFN would cover a geographically separate region. In the Greek plan, however, this does not appear to be the case, and many of the SFNs overlap, as seen in the example of Figure 5-6, below). We are, therefore, unclear as to why this approach has been adopted.

Since the SFNs in any given ΕΠΨΕ are all broadcasting the same content, there may be merit in using common frequencies for each multiplex within an entire

ΕΠΨΕ, at least in the case of the national stations where there is no regional variation[30].

Figure 5.16 Example of overlapping SFNs (ΕΠΨΕ 9, Athens / Attica region)



If a single frequency were to be used throughout the ΕΠΨΕ area for each multiplexes, this would free up frequencies that could be used to support additional stations in the future, or new services such as HDTV. The following table shows how many frequencies would be released in each ΕΠΨΕ if the multiplexes all used the same frequencies in that ΕΠΨΕ. It can be seen that replanning in this way has the potential to release six channels on a substantially national basis (the exception being ΕΠΨΕ 6 which has only one SFN currently. We hope to obtain further information on the practicality of such re-planning before the completion of this study.

[30] It will be necessary, if such an approach is adopted, to check that any two transmitters that serve the same coverage location should not be so apart that the specified guard interval is exceeded. For the 1/8 guard interval planned in Greece we estimate this distance to be approximately 34 km. It will also be necessary to check, using a suitable planning tool, that each frequency assignment does not cause interference with the same frequency in any other ΕΠΨΕ, though this is unlikely as the current SFNs largely overlap in the area they cover.

Table 5.8 Potential release of additional frequencies if common frequencies used for national multiplexes throughout ΕΠΨΕ area

ΕΠΨΕ	Area	Frequencies currently used in all SFNs	Multiplexes required	Frequencies that could be released
1	Western Greece, Epiros, Northern Eptanisa	20	9	11
2	Thessaloniki and Western Macedonia	19	8	11
3	Eastern Macedonia and Thraki	23	7	15
4	Thessalia	14	7	7
5	Boreio Aigaio, Samos-Ikaria	15	7	8
6	Eastern Central, Evrytania	10	8	2
7	Western Peloponnese, Ionian Islands	16	7	9
8	Eastern Peloponnese, Corinth	17	7	10
9	Attica, Cyclades	17	7	10
10	Dodecanese, Kastelorizo	14	8	6
11	Crete	18	8	10

5.14 Effect of removing digital dividend frequencies (channels 61 – 69) on transition frequency plan

The effect of removing the digital dividend frequencies prior to analogue switch off will affect the following sites during the transition phase. Note however that most of these sites will have at least one of the two current analogue subscription channels available which could be used to substitute for the digital dividend channel(s) lost. If this is the case only Παaka, Κρikeλo, Ξyλokaσtpo and Aiγina would have fewer multiplexes available if the digital dividend is removed. Note that although Ymhttoσ would lose one channel, both of the subscription channels would be available (as neither of these are currently included in the transition frequency plan).

Although these channels are currently reserved for mobile TV, we would suggest that given the current limited demand for this service experienced elsewhere in Europe and the ongoing uncertainty over technology it would be better to use these channels to supplement the transition DVB-T frequency plan if this would lead to an earlier release of the digital dividend frequencies.

Table 5.9 Effect of removing digital dividend frequencies prior to analogue switch off

Site	Digital Dividend (DD) channels used in transition period	Subscription TV channels (currently reserved for mobile TV)	Multiplexes available	
			With DD	Without DD**
ΚΕΛΛΗ	61	43*, 47	7	6 (7)
ΠΑΑΚΑ	64, 66	46*, 55	7	5 (6)
ΚΡΙΚΕΛΟ	63	-	7	6
ΞΥΛΟΚΑΣΤΡΟ	61, 64	-	7	5
ΥΜΗΤΤΟΣ	63	53, 58	6	6 (7)
ΑΙΓΙΝΑ	63, 65	54*, 60	8	6 (7)
ΡΟΓΔΙΑ	61	37*, 39	7	6 (7)

Notes: * frequency already included in transition frequency plan at that site

** figure in brackets assumes spare subscription TV channel is used

Other options to supplement the channels in the transition DVB-T plan, to allow the release of channels 61 – 69, is to identify alternative channels from the existing analogue frequency plan that can also be switched off at the sites affected.

6 TECHNOLOGY AND MARKET DEVELOPMENTS RELEVANT TO THE DIGITAL DIVIDEND AND NETWORK DEPLOYMENTS

There are a number of existing and ongoing developments that are driving interest in the digital dividend as well as technologies that may be able to facilitate the release of spectrum, for example, by enabling digital TV services to use spectrum more efficiently.

6.1 Mobile Broadband Services

Third generation mobile technology has evolved considerably since the first services were launched at the turn of the century. The original UMTS standard (Release 99) catered for peak bit rates of up to 2 Mbps, although in practice these were more typically constrained to 384 kbps. Within four years, a new standard had emerged called High Speed Packet Access (HSPA) which promised peak rates of up to 14.4 Mbps in the same 5 MHz channel – though again typical rates were somewhat lower, in the range 3.6 – 7.2 Mbps. HSPA also provided significant improvements in the throughput available within 3G mobile networks, enabling operators to launch more cost-effective service offerings including flat rate data plans for monthly tariffs as low as €10.

The improved performance and lower cost of 3G services has stimulated the market for mobile broadband to the extent that in some markets mobile technology has a significant share of the wider broadband market. This is particularly the case in countries such as Greece where fixed broadband penetration is relatively low – according to a recent European Commission report mobile broadband penetration in Greece is almost twice the EU average and mobile accounts for approximately half of all broadband connections[31]. This would suggest strong potential future demand for additional spectrum to support growth in mobile broadband services in Greece.

The need for cost effective wireless broadband in rural areas is also reflected in the Government's Strategy for Electronic Communications and ICT for the period 2008-2013, announced in February 2008 by the Minister of Transport and Communications. Whilst this includes a €2.1 billion investment in a fibre optic network, this will be focused on large urban areas. In more remote areas the emphasis will be on wireless access and cost effective rollout in these areas is likely to depend on access to sufficient spectrum in harmonised bands below 1 GHz. Delivery of services comparable to those available over fixed platforms (xDSL) will require the latest wireless broadband technologies.

[31] source: COCOM08-41 Final, EC Communications Committee Working Document on Broadband access in the EU: situation at 1 July 2008

Further evolution of the 3G standards over the next few years is expected to drive peak data rates as high as 100 Mbps, but will require wider radio channels to support this – potentially up to 20 MHz per carrier, equivalent to over half the existing 900 MHz cellular band. Economic rollout of competing mobile broadband services is therefore likely to require further spectrum to support these higher bandwidths and this is clearly one contender for any digital dividend spectrum, especially as at the World Radio Conference in 2007 governments from Europe, Middle East and Africa identified the band 790 – 862 MHz for mobile broadband services.

6.2 Broadcast Technology Options

The current DVB-T[32] standard, which was originally published in March 1997, has already been deployed in more than 35 countries with many more set to launch in the coming years. It is a mature and well established standard, and provides the benefits from economies of scale (very low receiver prices) but is flexible enough to enable a wide range of business models.

DVB-T2[33], the recently adopted (summer 2008) upgrade to the DVB-T standard offers very significant capacity improvements, as well as other benefits. The principal changes in the new standard are a greatly improved coding scheme (using LDPC/BCH codes) which approaches the Shannon limit as closely as is practicable, combined with the use of higher-order modulation (256 QAM). Other improvements (longer interleaving and the use of 'rotated constellations') add robustness in the face of impulsive noise and adverse propagation channels.

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[32] DVB-T is a 'stack' of component technologies with each part building on the functions provided by the lower parts. The component technologies are:

- Data transmission: COFDM using 16 QAM (4 x 4 sub carriers) and 64 QAM (8 x 8 sub carriers), 2k carrier, with Viterbi?RS forward error correction
- Multiplexing and service definition: MPEG-2 multiplexing
- Video coding: MPEG-2 (720 pixels on 576 lines, 25 frames per second)
- Audio coding: AAC and Layer III

[33] DVB-T2 updates each component technology to improve the performance:

- COFDM uses 256 QAM (16 x 16 sub-carriers), and a more efficient error-correction system (LDPC / BCH and 32k carriers)
- MPEG-4 video encoding
- Higher resolution: (up to 1680 pixels on 1080 lines)
- Better audio (e.g. Dolby Digital)

Taken together, early laboratory trials suggest that these improvements can increase the data capacity of a single 8 MHz channel by as much as 50%, without changing the planning assumptions (i.e. there is no requirement to increase transmitter powers or to tolerate smaller coverage areas). This figure, which has yet to be confirmed in large-scale field trials, is significantly in excess of the original target of a 30% improvement. The system also allows more planning flexibility by permitting SFNs to cover a wider geographical area.

Also the DVB-T2 System is designed from the outset to be received by existing domestic DVB-T antenna systems and to co-exist with existing DVB-T transmissions. The new MPEG–4/H.264 video codec can be used alongside DVB-T2 , and is approximately twice as efficient as the MPEG2-video codec used for standard definition channels.

Products and services using DVB-T2 are intended to be available commercially from 2009 and a typical scenario could be the launch of high definition TV services over DVB-T2 on new frequency allotments alongside existing standard definition TV services using DVB-T, after analogue broadcasts end. The UK will be carrying out large-scale field trials of the new standard in London during the spring and summer of 2009, and the first services will be launched in the densely-populated region of the North-West of England in November 2009.

It should be noted that MPEG-2 and MPEG-4 are not part of the DVB-T and DVB-T2 standards. Video (TV programs) that have been compressed by either of the standards can be transmitted by both DVB-T and DVB-T2 and MPEG-4 is already used with DVB-T in France and Norway (further information on the compression formats that are deployed or planned in other countries can be found in Annex D). Using different modulation (e.g. 16 QAM instead of 64 QAM) will allow the coverage to be modified provided the transmitter power remains the same. In the UK for example the BBC have used 16 QAM on Mux 1 and Mux B to provide better coverage and once switchover occurs, and powers can be increased, the BBC will revert to 64 QAM.

In the Greek context, there are clearly concerns relating to the availability of transmitter and consumer equipment and the potential delay to DTT roll-out, but the advantages in spectrum efficiency of the DVB-T2 standard seem to be so great that it might be unfortunate to entrench the older standard at this late stage. The UK, having established a very large population of consumer equipment that is incompatible with DVB-T2, will have significant problems in managing a transition to the new standard, which will inevitably take many years; Greece is in the fortunate position of having the opportunity to avoid this, and to establish a highly efficient DTT network. No changes to the current DTT frequency plan would be required to accommodate DVB-T2.

6.3 Network Design Options

There have been two approaches adopted to the design of the DTT networks; MFN (multi-frequency network) or SFN (single-frequency network). In a MFN network different frequencies are assigned to each site and coverage is provided by a transmitter. In the case of a SFN network the same frequency is assigned to all sites, which must be accurately synchronised must carry the same content. Every transmitter contributes to provide the coverage and cannot operate independently.

In the case of a SFN implementation there are a number of alternative approaches that can be adopted by using:

- A few high power stations
- More stations with lower radiated power
- Main stations complemented by gap-filler (low power stations).

Furthermore, SFNs may be implemented on a national scale or on a regional basis. The main drawbacks to the use of SFNs is that some data capacity must be sacrificed to provide sufficient 'guard-interval, and that the possibility of providing localised content is lost.

The benefits of a SFN is better spectrum efficiency, allowing a higher number of radio and TV programs in comparison to traditional multi-frequency network (MFN) transmission in the same amount of spectrum. An SFN may also increase the coverage area and decrease the outage probability in comparison to an MFN, since the total received signal strength may increase to positions midway between the transmitters - this factor is generally most important for networks intended for mobile or portable reception, where non-directional receive aerials are used.

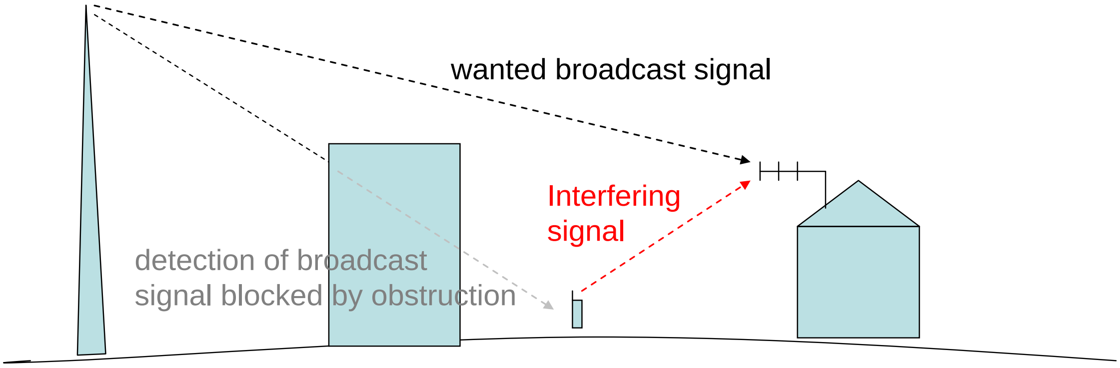
The network design adopted in Greece is based on the regional use of SFNs. It is noted that in some ΕΠΨΕs there are more than one SFN and our understanding is this was necessary to achieve the required coverage. Whether there is the possibility to adopt an alternative approach, such as using gap-fillers, and thereby reducing the channels required is unclear.

6.4 "White Space" Technologies

There is strong interest in the US in particular in the deployment of "cognitive" radio technologies in parts of the TV broadcast spectrum. These technologies take advantage of the gaps in utilisation of the UHF frequencies, by detecting which frequencies are in use for TV transmission at a particular location and using the remaining frequencies for relatively low power transmissions that could be used for fixed or mobile wireless applications. These locally unused TV frequencies are sometimes referred to as "white spaces" within the band. The technologies are not specifically aimed at the digital dividend spectrum since they are intended to share spectrum with TV broadcasts and do not require exclusive spectrum allocations. In the US the FCC has ruled that unlicensed devices that can guarantee that they will not interfere with broadcasting can use the white spaces.

Essentially there are two types of cognitive radio system that could use white spaces. The first relies on physical monitoring of the spectrum to detect whether a broadcast signal is present at a particular location, whilst the second uses knowledge of the geographic location to determine whether a frequency is in use at that location. Both approaches present challenges. Monitoring required a highly sensitive receiver to detect the presence of TV broadcasts and is susceptible to the "hidden node" effect, where the cognitive device is shielded from the broadcast transmitter (therefore fails to detect the broadcast signal) but is not shielded from the TV receive aerial and so could cause interference to TV reception.

Figure 6.1 Illustration of "hidden node" scenario with cognitive radio device



To overcome the hidden node problem it is necessary to factor in a significant additional margin to cover the additional attenuation of the broadcast signal at the cognitive device.

The alternative approach using relocation is also challenging as positioning systems like GPS do not work indoors and alternative techniques such as triangulation between cellular base stations or other fixed sites may not be sufficiently accurate and may not provide height information. This could lead to interference arising if a cognitive device was used on the upper floor of a tall building, for example.

A recent consultation document by the UK regulator Ofcom[34] suggested various technical parameters that might be applied to the two approaches. A relatively low power limit of 100 mW is proposed for the auto-sensing approach. In the US, the rules recently adopted require both autosensing and geolocation to be used in most cases and limit the power for mobile devices to 100 mW. Up to 4 W is permissible for fixed devices, which could make the technology suitable for delivery of wireless broadband services.

[34] "Digital dividend: cognitive access. Consultation on licence-exempting cognitive devices using interleaved spectrum", February 2009 (http://www.ofcom.org.uk/consult/condocs/cognitive/cognitive.pdf)

7 INTERNATIONAL COORDINATION ISSUES

According to the GE06 Plan, once digital switchover is completed, or after 17 June 2015[35], there is no requirement to co-ordinate any of the channels that are allotted to Greece with other countries. During the switchover period Greece will need to co-ordinate some of the digital channels with the analogue channels of the following neighbouring countries: Bulgaria, Croatia, Egypt, Italy, Libya, the former Yugoslav Republic of Macedonia, Serbia and Montenegro and Turkey.

The requirement for coordination is based on the assignments and allotments that were agreed at the Planning Conference and do not take account of whether coordination would be required if Greece were to re-allocate Chs 61 – 69 (790 – 862 MHz) to other services. It has also been noted that as part of the planning process Greece did not notify that the spectrum currently allocated to the military required protection so Chs 67 – 69 will not have been afforded any protection from cross-border interference.

If the majority of the neighbouring countries to Greece adopt the harmonised approach to release 790 – 862 MHz for non-broadcasting applications such as mobile services it will place fewer restrictions on the spectrum use. Cross-border agreements are already established for mobile services in other frequency bands and it should be feasible to do the same for the “800 MHz” band.

7.1 Coordination with Italian DTT

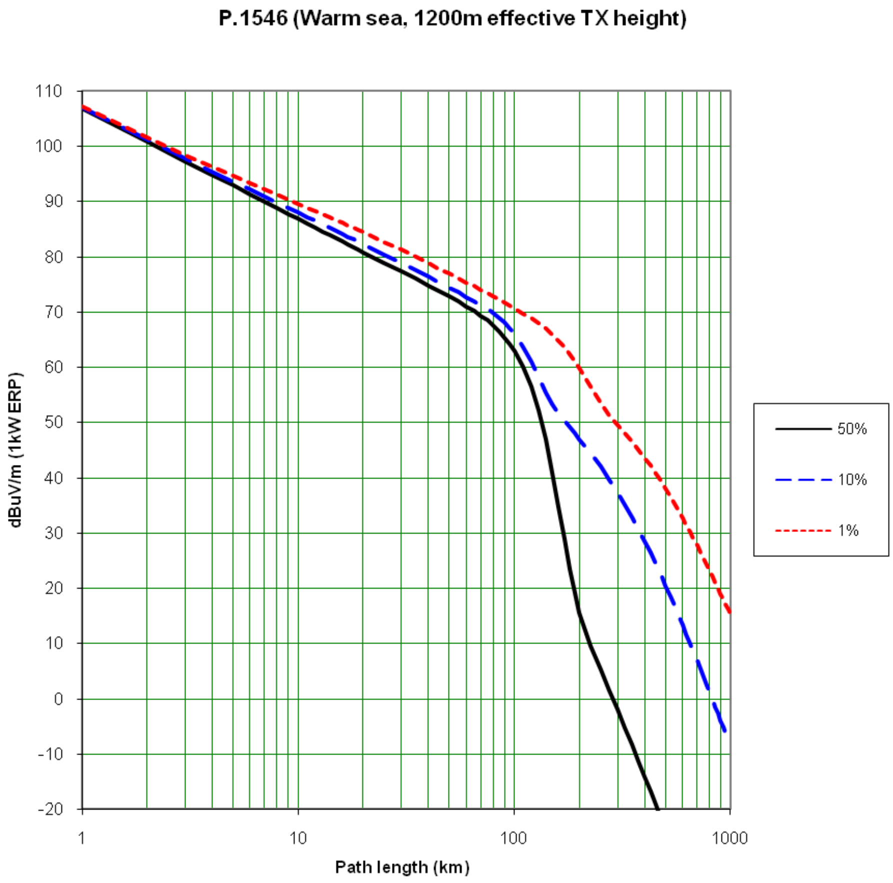
It has been noted that Italy is currently strongly opposed to adopting the proposed harmonised approach to spectrum release above 790 MHz, and the possibility therefore exists that this spectrum will continue to be used for DTT in Italy.

As has been noted above, the primary interference concern relates to the possibility of interference into cellular base station receivers from high power DTT transmitters. Given the large distances involved (>400km), there will be no possibility of long-term interference to cellular services at levels that would have any impact on coverage. The situation for small percentage-times is rather different.

The curves below are taken from ITU-R Recommendation P.1546-2, which formed the basis for the compatibility calculations undertaken in the GE-06 planning process.

[35] As part of the Geneva 2006 (GE-06) Agreement, national administrations will end analogue transmission along their borders by 17 June 2015. This aligns with the European Commission's recommendation that Member-States phase out analogue terrestrial broadcasting by 2012.

Figure 23: ITU-R Propagation curves



It can be seen that, for path lengths of around 500km, levels of interference increase by around 40dB at 10% time and 60dB at 1% time. For a typical 10KW (ERP) DTT transmitter, this will give rise to incoming interference fields of around 38dBμV/m for 1% time. This value is adequate for DTT reception, and is significantly in excess of the interference limits being considered by SE42 for the protection of cellular base station receivers.

In practice, however, the impact of continued Italian use of the sub-band for DTT will be limited. As has been discussed above, the cellular uplink (i.e. mobile transmit, base station receive) will operate in channels 66-69. Examining the Italian GE06 plan shows only a few high power (ERP of 40dBW and above) assignments, and the locations of these are illustrated below.

Figure 7.1 High-power Italian DTT sites in Channels 66-68

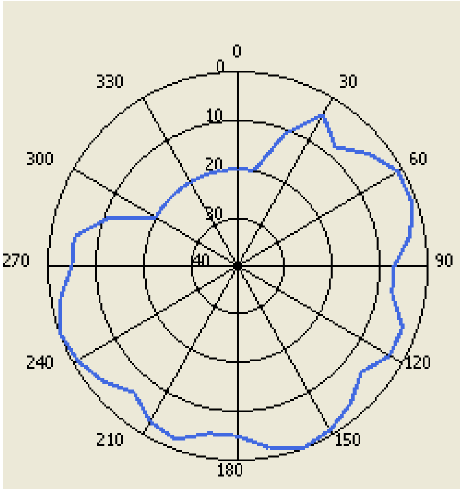
The characteristics of these sites are indicated in the table.

Table 7.1 Italian DTT sites with potential to cause interference to mobile base stations

Name	Channel	ERP	Pol	Height (asl)
Scrisi	66	43 dBW	V	667 m
M. Virgine	66	44 dBW	H	1842 m
Fiuggi	67	40 dBW	H	777 m
M. Soro	67	40 dBW	H	1850 m
Valverde San Gregori	67	42 dBW	H	367 m
M. Poro	68	46 dBW	H	687 m

Of these sites, those at M. Virgine and M. Soro (Sicily) are likely to cause the most significant interference, owing to their elevated locations. The path lengths from these two sites to Corfu are 450 km and 480 km respectively. M. Virgine has an omnidirectional antenna pattern, while that at M. Soro provides no useful protection towards Greece.

Figure 7.2 Radiation pattern of M. Soro transmitter



The following maps show the likelihood of interference arising for more than 1% of the time, based on ITU Recommendation P.1812. Contours correspond to >0dBuV/m (red) and >10dBuV/m (yellow). The lowest interference threshold for mobile base stations currently being proposed by CEPT is 11.6 µV/m, i.e. any of the coloured areas may be regarded as having the potential to suffer interference. It should be noted that the propagation model does not fully take account of the specific attributes of the Mediterranean area. We therefore recommend that a long term monitoring exercise should be carried out in the areas likely to be affected to assess more thoroughly the likely impact of Italian TV transmissions on Greek mobile services, prior to the launch of these services.

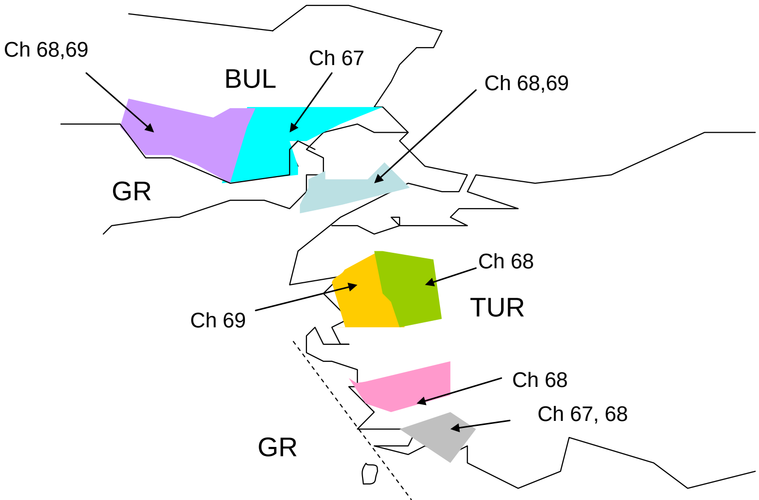
Figure 7.3 Projected interference from TV transmissions on Mt Virgine, Italy, into a 3G mobile base station (height 10 metres)

Figure 7.4 Projected interference from TV transmissions on Mt Soros, Italy, into a 3G mobile base station (height 10 metres)

7.2 Planned use of channels 67 – 69 in Bulgaria and Turkey

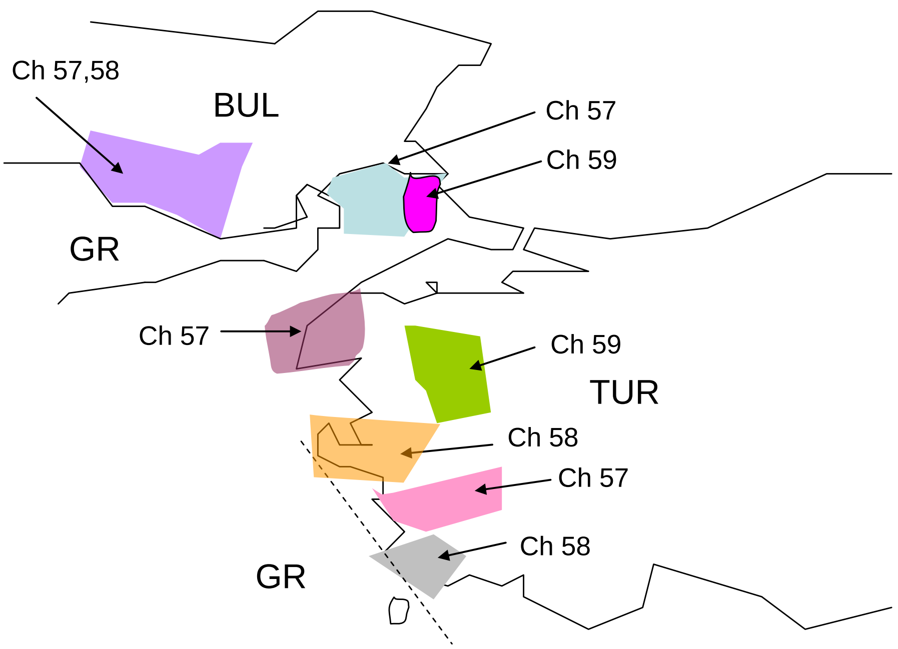
According to the74 GE-06 plan there are a number of allotments to Bulgaria and Turkey that area located on or near the Greek border and include channels 67 – 69. As these frequencies are not protected in the GE-06 plan for Greece there is a risk that interference will arise either to future public mobile services (though that would be mitigated if these countries adopt the harmonised digital plan) or to military systems if the channels are retained for this purpose. The map below shows the approximate location of the allotments making use of these channels.

Figure 7.5 Planned use of channels 67 – 69 in Bulgaria and Turkey



There is also some planned use of channels 57 – 59 in Western Turkey and Southern Bulgaria so any migration of the military systems to these channels should take this into account.

Figure 7.6 Planned use of channels 57 – 59 in Bulgaria and Turkey



8 CONCLUSIONS AND RECOMMENDATIONS

A number of key conclusions and recommendations for future action have emerged from this study. These are summarised in the following sections.

8.1 International Situation

Although there is not yet a universal consensus, there is growing support internationally for the adoption of a harmonised release of spectrum at the top of the UHF broadcast band for use by mobile services, i.e. 790 – 862 MHz or channels 61-69 inclusive. Demand for this spectrum exists because in most countries the existing cellular spectrum below 1 GHz is fully utilised by GSM services and there is insufficient spectrum in the GSM900 band to allow competing operators to deploy IMT / LTE services whilst continuing to support GSM services, or in the longer term to deliver higher bandwidth LTE services. Although bands above 1 GHz exist, these are unlikely to be economic for providing coverage in rural areas. Hence cost effective expansion of mobile broadband services is likely to depend on access to additional spectrum below 1 GHz, which in practice means the 790 – 862 MHz band.

8.2 Implications for Greece

The impact of the release of additional spectrum below 1 GHz for mobile services is likely to be greatest in those countries that have the greatest reliance on mobile technology for the delivery of broadband services. Greece currently has one of the lowest levels of fixed broadband availability in the EU but one of the highest levels of mobile broadband penetration. The Government's strategy for electronic communications and ICT for the period 2008-2013 makes clear that the emphasis in rural areas will be on wireless access rather than xDSL. The absence of a cable broadband option in Greece also means mobile broadband may play a bigger role in providing a competitive alternative to xDSL than in other countries where cable is an option. All of these factors strengthen the case for releasing the harmonised digital dividend in Greece.

8.3 Impact of releasing the harmonised digital dividend

Our analysis has shown that the release of the frequencies above 790 MHz will have no impact on the ability to deliver all the planned national digital TV stations and to maintain all of the regional stations authorised in Decision 15587 and its subsequent amendments. The existing frequency plan can be retained

8.4 Requirement for channels 67 – 69

In order to realise the benefits of the harmonised digital dividend for mobile broadband access it will be necessary to ensure that the entire 2 x 30 MHz that has been identified by CEPT is made available in as much of the country as possible. If channels 67 – 69 are not made available the amount of spectrum for mobile broadband services will be reduced to just 2 x 5 MHz and much of the benefit will be lost. A number of options exist for dealing with the existing military use of these channels, including:

i) migrating the military use to a similar sized block (24 MHz) below 790 MHz

ii) retaining 8 MHz of the military use in channel 65 (the duplex gap in the proposed harmonised military band) and migrating the remaining 16 MHz to below 790 MHz

iii) Migrate to another band and/or technology (several other countries have migrated equipment from the 610 – 960 MHz band to other core military bands)

Adopting the first or second option appears to have minimal impact on the ability to deliver the required multiplexes (the third option clearly has no impact but may incur more costs or disruption for the military users).

Any cost incurred by the military could if necessary be recouped as part of the spectrum award process.

8.5 Potential release of other spectrum beyond the harmonised digital dividend

We have identified that up to a further 40 MHz of contiguous spectrum in the range 526 – 596 MHz could be released whilst still delivering the required number of national and regional multiplexes (a minor reconfiguration of the current plan may be required in one ΕΠΨΕ). This spectrum could be used to meet the needs of PMSE, public safety, or new broadcast services such as HDTV (note that frequencies may require co-ordination with neighbouring countries if high power transmissions are deployed). Note that the amount of additional spectrum will be reduced to 32 MHz if all of the current military use is migrated below 790 MHz as per option (i) above, but would not be reduced with option (ii). Release of this additional spectrum is, however, not as important as releasing the digital dividend as the possibility of harmonisation is low.

8.6 Implications of neighbouring countries not adopting the harmonised digital dividend

It is possible that some neighbouring countries (notably Italy) may not adopt the harmonised digital dividend and may retain high power TV transmissions in the 790 – 862 MHz band. Our analysis of the potential interference to mobile services indicates that the impact on Greece will be marginal and unlikely to be a significant constraint on the delivery of mobile broadband services.

ANNEXES

A CURRENT CEPT ACTIVITY RELATING TO THE DIGITAL DIVIDEND

A.1 Introduction

In response to the EC mandate referred to above, CEPT Report 22 was developed[36]. This report concluded that the preferred sub-band for a harmonised digital dividend was the upper part of the UHF band and should include *as a minimum* channels 62 to 69 inclusive (798 – 862 MHz). The EC subsequently issued a second mandate to the CEPT on specific issues that required study in the band 790 – 862 MHz band, which was identified for mobile services at WRC-07. The mandate comprised the following elements:

- The identification of common and minimal (least restrictive) technical conditions to avoid interference and facilitate cross-border coordination.
- The development of the most appropriate channelling arrangements that will facilitate the development of EU-wide equipment but also allow Member States to adapt them to national circumstances and market demand.
- A recommendation on the best approach to ensure the continuation of existing Programme Making and Special Events (PMSE) services and if possible the development of an EU-level solution.

The main deliverables will be additional reports[37] and the planned delivery dates are shown below:

- Final report on technical conditions, draft final report on channelling plan and progress report on PMSE. This was originally due for publication in March 2009 but has been delayed until the end of May when PT SE 42 meet again..
- June 2009: Final reports on channelling plans and PMSE.

The distribution of this work within CEPT's European Communications Committee (ECC) is:

- Task 1 – Technical conditions.
- Task 2 – Channelling arrangements.
- Task 3 – Cross border coordination issues.

These three tasks are described in more detail in the following sections.

[36] Report B from CEPT to the European Commission in response to the Mandate on: "Technical considerations regarding harmonisation options for the Digital Dividend" on 1 July 2008.

[37] See ECC PT1(09)039 ANNEX 6

A.2 Task 1 - Technical Conditions

CEPT Spectrum Engineering Project Team 42 (SE 42) was the lead group on technical conditions in the band 790 – 862 MHz. Draft CEPT Report 30, "The identification of common and minimal (least restrictive) technical conditions for 790 – 862 MHz for the digital dividend in the European Union" is an input document into the ECC Meeting (June 22nd – 26th).

The technical conditions developed in this report are not dependant on the channel arrangements and can be applied to various band plans with a 5MHz block size. The report also considers the minimum technical conditions that applications such as PMSE operating in, for example, the FDD duplex gap must meet.

The definition of the least restrictive technical conditions is based on the block edge mask (BEM) approach and consists of in-block and out-of-block limits depending on frequency offset. The out-of-block component of the BEM consists of a baseline limit as well as transitional (or intermediate) limits, to be applied, where applicable, at the frequency boundary of an individual spectrum licence. These limits were derived using studies (of appropriate compatibility and sharing scenarios) between ECN and other applications in adjacent bands but in the same geographical area. The block edge masks, however, do not provide full protection of victim services and to resolve the remaining cases of interference additional mitigation techniques may need to be applied and possible approaches are provided in Annex 4 of the draft report.

In adjacent geographical areas (co channel or adjacent bands), the BEM has to be applied in conjunction with other conditions necessary for the coexistence between ECN systems and other applications. This can be done at a national level by deriving power flux density (pfd) values for areas within the territory of one administration or with cross-border coordination developed by bilateral or multi-lateral agreements.

The following text is taken from the Executive Summary of the draft report and provides an overview of the conclusions:

"Compatibility of ECN base stations with high power terrestrial broadcasting

Simulations over a range of scenarios indicate that the fraction of locations in which a TV receiver may suffer unacceptable levels of interference (*failure rate*) does not improve significantly with a reduction in the ECN BS BEM baseline below 0 dBm/(8 MHz), based on typical measured values for ACS and on a range of high EIRP of the base station (≥59 dBm/10MHz). However, for lower EIRP levels, this fraction of locations in which a TV receiver may suffer unacceptable levels of interference (failure rate) shows significant improvement with a reduction in the ECN BS BEM baseline.

The different set of studies realised so far show that the impact of interference can not be arbitrarily reduced through a reduction of the BS out-of-block (OoB) emission alone due to finite TV receiver selectivity. Therefore, other mitigation mechanisms (beyond the BEM baseline level) would ultimately be required if the protection delivered by the BEM only is considered insufficient by an administration, e.g. by means of protection clause.

This conclusion is valid for situations where the first ECN adjacent channel to a DTT channel is used. In that case, the MCL analysis gives an idea of the extent of this interfered area located around each ECN base station. It has also to be noted that a baseline of 0 dBm/8 MHz may result in a significant constraint for ECN base station when the TV channel is adjacent to the ECN block (e.g. in the case of channel 60) and that it may not be necessary in areas where frequency offset between DTT channel and ECN channels is higher. On the other hand, it was also noted that broadcasting planning may evolve and that a channel not used in an area may be used in the future, after deployment of ECN base stations.

Therefore, it can be suggested that, in the case of the implementation of the full sub-band 790-862 MHz for ECN networks, OOB BEM for base station would be as follows:

Situation	Description	Condition on base station e.i.r.p. P (dBm/10MHz)	Maximum mean out-of-block EIRP	Measurement bandwidth
A	For DTT frequencies where broadcasting needs to be protected	P ≥ 59	0 dBm	8 MHz
		44 ≤ P < 59	(P-59) dBm	8 MHz
		P < 44	-15 dBm	8 MHz
B	For DTT frequencies where broadcasting requires an intermediate level of protection	P ≥ 59	10 dBm	8 MHz
		44 ≤ P < 59	(P-49) dBm	8 MHz
		P < 44 dBm	-5 dBm	8 MHz
C	For DTT frequencies where broadcasting does not need to be protected	No condition	22 dBm	8 MHz

For the protection of terrestrial broadcasting operating adjacent to mobile/fixed communication networks, baseline requirement mentioned in situation “A” shall be applied at least on DTT channels in use. For DTT channels which are not in use when implementing ECN base station, an administration can choose between the baseline requirements mentioned in situations “A”, “B” or “C” on a national basis. The intermediate level of protection in situation “B” can be justified in some circumstances (e.g. agreement between broadcasting authority and mobile operators).

These conditions have been derived from studies related to the protection of fixed outdoor reception for DTT. However, they are also applicable to the protection of the portable DTT reception modes as it was shown by additional studies, following the same methodology as for studies related to protection of fixed reception.

Compatibility of ECN terminal stations with high power terrestrial broadcasting

An ECN terminal baseline requirement of -50dBm/8MHz for frequencies below 790 MHz is needed for protection of fixed TV reception. In the case of protection of portable TV reception, an ECN baseline of -65 dBm/8 MHz would be needed. The uplink guard band to protect DVB-T fixed reception from ECN uplink interference on an adjacent channel is around 7 MHz. For the preferred FDD channel arrangement, the frequency separation between uplink and DVB-T is 42MHz; the guard band requirement is therefore inherently met and the baseline level is readily met. Therefore, this does not have to be a requirement imposed to FDD terminal station when the preferred channel arrangements are used.

Compatibility between ECN networks

A similar approach to the one used in CEPT report 19 and ECC report 131 has been applied. A baseline limit of -49dBm/5MHz in the relevant part of the spectrum has been derived for the ECN base stations, and of -37dBm/5MHz for ECN terminal stations. Some transitional levels are also introduced to ease the transition between operators. They are derived from the LTE band-independent spectrum emission mask, which has been assumed to be representative of the technologies envisaged in this band.

In-Block EIRP

An administration may specify a base station in-block EIRP limit. Based on compatibility studies and deployment requirement, suggested maximum EIRP limits range from 56 dBm/(5 MHz) to 64 dBm/(5 MHz). In case a limit is specified, administrations may consider authorising a power exceeding the limit in particular situations, e.g. in rural areas.

The limit for ECN terminal station in-block power is 25dBm. Administrations may relax this limit in certain situations, for example fixed installations in rural areas.

It may be necessary to use band pass filters at DVB-T receivers in order to be sufficiently protected against interference caused by this in-block EIRP limit, This is particularly important for portable reception.

These different values constitute the set of least restrictive technical conditions, to be met by an ECN operating in the 790-862MHz band.

It should be noted that Administrations should ensure that mobile/fixed communication network operators in the 790-862 MHz band are free to enter into bilateral or multilateral agreements to develop less stringent technical parameters and, if agreed among all affected parties including broadcasting operators.”

A.3 Task 2 - Channelling arrangements

ECC Project Team 1 was the lead for channelling arrangements in the 790 – 862 MHz band and has produced Draft CEPT Report 31, which has been input to the

ECC meeting in June, for approval prior to public consultation. This draft report provides information on the background considerations that resulted in the development of the preferred harmonised frequency arrangement which is 2 x 30 MHz with a duplex gap of 11 MHz and block sizes of 5 MHz paired and with reverse duplex direction (see the figure below). Individual administrations which do not wish to use the preferred harmonised frequency arrangement or do not have the full band available have the option of considering:

- partial implementation of the preferred frequency arrangements
- TDD frequency arrangement
- mixed TDD and FDD frequency arrangement, or
- implementation of a 1 MHz raster.

The advantages of a preferred harmonised frequency arrangement are mentioned in the draft report and in an earlier draft reference was made to analysis undertaken by the GSM Association[38] which showed the cost penalty of adopting a non-harmonised approach. According to this analysis, country-specific allocations are intrinsically uneconomic and without a harmonised band handset costs could be prohibitively high (up by 50% or more depending on the market size) which would lead to a significant reduction in take-up of any mobile services in the band.

Also in the draft report mention is made of possible uses of the FDD plan duplex gap or a TDD plan guard band on a national basis and notes that compatibility studies are required to protect mobile usage (uplink and downlink) before a decision is made.

- PMSE especially radio microphones;
- Low power applications ("restricted blocks", taking into account protection of FDD);
- Low power IMT applications;
- Other national systems e.g. Defence systems.

The ECC has concluded that studies in CEPT should assume the use of wireless microphones noting that the resulting technical framework might also be used by other applications.

In addition a Draft ECC Decision on the harmonised conditions for Mobile/Fixed Communications Networks operating in the band 790 – 862 MHz was approved at the 32nd ECC PT1 meeting at the end of April to go to the ECC meeting in June for approval prior to public consultation. This document defines the channelling arrangements and the preferred harmonised frequency arrangement (FDD) is provided in Annex 1 and is based on a 2 x 30 MHz FDD plan with a 1 MHz separation at 790 MHz to 791 MHz and a 11 MHz duplex gap. The 1 MHz

[38] See http://www.gsmworld.com/documents/gsma_white_tech_note.pdf

frequency separation assumes that it would be possible for mitigation techniques to be implemented to protect DTT reception and it is proposed by ECC PT1 that in the text for public consultation industry stakeholders should be invited to provide comments on this approach.

791-796	796-801	801-806	806-811	811-816	816-821	821 - 832	832-837	837-842	842-847	847-852	852-857	857-862
Downlink						Duplex gap	Uplink					
30 MHz (6 blocks of 5 MHz)						11 MHz	30 MHz (6 blocks of 5 MHz)					

Annex 2 to the draft Decision provides guidance for Administrations not implementing the preferred frequency arrangement and includes a TDD plan:

790-797	797-802	802-807	807-812	812-817	817-822	822-827	827-832	832 – 837	837 – 842	842 – 847	847-852	852-857	857-862
Guard band	Unpaired												
7 MHz	65 MHz (13 blocks of 5 MHz)												

Annex 3 provides the technical conditions for base stations and terminals based on the BEM approach. This work was undertaken in PT SE42.

A.3.1 Task 3: Cross border coordination issues

ECC Task Group 4 (TG4) is the lead group for cross border issues. The Group is also responsible for dealing with PMSE issues. The Group was worked on four deliverables, namely:

- Deliverable A – “Guideline on cross border coordination issues between mobile services in one country and broadcasting services in another country”
- Deliverable B - “Recommendation on the best approach to ensure the continuation of existing PMSE services operating in the UHF band (470-862 MHz), including the assessment of the advantage of an EU-level approach”
- Deliverable C – “Report / Recommendation on rearrangement activities for broadcasting services in order to free the sub-band 790 – 862 MHz”.
- Deliverable D – “Report on measurements of protection ratios for the protection of the broadcasting service from the mobile service in order to assist administrations in determine the precise situation in terms of compatibility”.

These deliverables are discussed in more detail in the following sections:

A.3.1.1 Deliverable A – Guidelines on cross border coordination issues between mobile services in one country and broadcasting services in another country (CEPT Draft Report 29)

This report is intended to provide a range of guidelines for coordination which can be selectively chosen by administrations when establishing their coordination methodologies with neighbouring countries. The conclusions / proposals are based on the following assumptions:

- UHF channels 61 – 69 can be used for mobile services
- The regulatory framework given by the GE-06 Agreement is retained
- The rights associated to the GE-06 Agreement shall be retained unless otherwise agreed by the concerned administrations.

At the time of writing CEPT Draft Report 29 had been out for public consultation and no comments had been received prior to the response deadline of 10th May 2009. The results of the public consultation were on the agenda for the June ECC meeting (22nd – 26th June).

The Draft Report notes that *"incoming co-channel and overlapping channel interference from broadcasting networks into mobile service base stations in areas adjacent to the border is likely to be the main issue"*. The rationale for this conclusion is that: the transmit powers and antenna heights characterising broadcasting networks are considerably higher than those encountered within typical mobile networks and may create substantial interference over a wide area. Furthermore, as FDD operation requires two paired channels, the mobile network may in general be subject to two different coverage patterns of incoming DTT interference. Furthermore, broadcasting and mobile services are expected to have different channel widths which mean that interference from multiple and partially overlapping channels will generally have to be taken into account.

Analysis conducted in the UK and France on the impact of the GE06 Plan on deployment of fixed/mobile services suggests that the limiting case for mobile network operation in the 790-862 MHz band will be mobile base station reception in the presence of incoming interference from digital television transmissions in neighbouring countries operating in this frequency band, rather than in meeting outgoing interference thresholds to protect digital television reception. Incoming (and outgoing) interference levels vary considerably on a channel-by-channel basis across the band 790-862 MHz.

The Draft Report also notes that if countries do harmonise the channels 61 – 69 for mobile services cross-border co-ordination will need to be developed similar to that specified in ECC Rec (08)02 for GSM and other services in the 900 MHz band. The Draft Report defines trigger field strengths for international co-ordination, based on the GE-06 Agreement as listed below:

Table A-1 Co-ordination trigger values to protect Broadcasting and Mobile Service at common height of 20 metres

Coordination trigger field strength for the protection of the Broadcasting Service	
Protection of analogue TV	*22 dBµV/m/8 MHz at 10 m at the border*
Protection of digital TV	*25 dBµV/m/8 MHz at 10 m at the border*
Coordination trigger field strength for the protection of the Mobile Service	
Protection of mobile station	*31,2 dBµV/m/8 MHz (NB) at 1,5 m*
Protection of base station	*18 dBµV/m/8 MHz (NA) at 20 m* *14,6 dBµV/m/8 MHz (NB) at 20 m*

"NA" and "NB" codes, as contained in the GE-06 agreement, are the system types for mobile services which most closely correspond to likely mobile development in the band 790-862 MHz.

With this information, coordination trigger values in the table are also adjusted in the Draft Report for a common height of 10 metres, as follows:

Table A-2 Co-ordination trigger values to protect Broadcasting and Mobile Service at common height of 10 metres

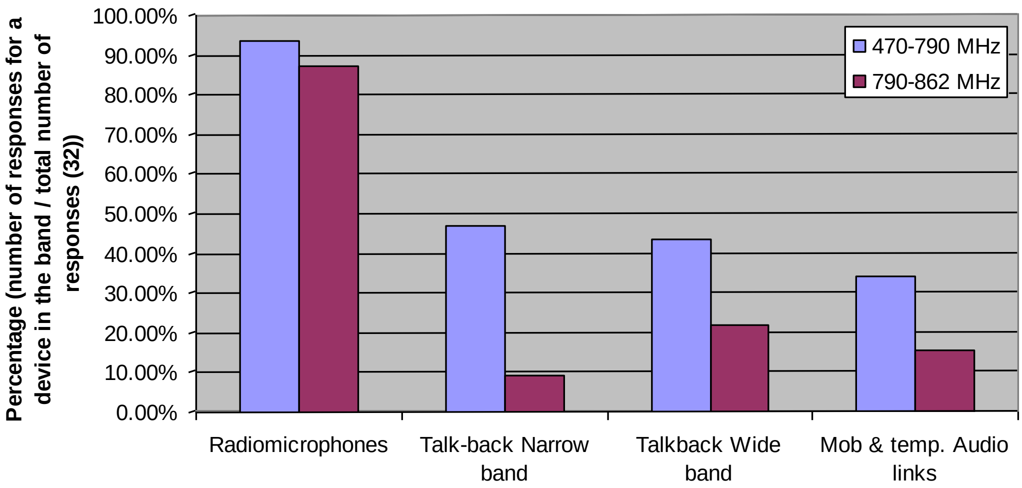
Coordination trigger field strength for the protection of the Broadcasting Service at 10m	
Protection of analogue TV	*22 dBµV/m/8 MHz at the border*
Protection of digital TV	*25 dBµV/m/8 MHz at the border*
Coordination trigger field strength for the protection of the Mobile Service at 10m	
Protection of mobile stations	*49.2 dBµV/m/8 MHz (NB)*
Protection of base stations	*11.6 dBµV/m/8 MHz (NA)* *8.2 dBµV/m/8 MHz (NB)*

A.3.1.2 Deliverable B – Report from CEPT to the European Commission in response to the Mandate on "Technical considerations regarding harmonisation options for the digital dividend in the European Union". "Recommendation on the best approach to ensure the continuation of existing PMSE services operating in the UHF (470-862 MHz), including the assessment of the advantage of an EU-level approach"

The Draft CEPT Report 32 has been submitted for approval to go out for public consultation at the ECC June meeting. The report investigates approaches needed to ensure that PMSE systems can continue to operate in the UHF band as well as alternative common solutions outside the UHF band.

The figure below, from the draft report, and provides an overview of the different PMSE applications and how they are distributed across the 470 – 790 MHz and 790 – 862 MHz bands.

Figure A-4 Overview of broadcasting applications used in the band 470 – 862 MHz



In EBU Report 001 it was noted that in the 470 – 862 MHz band, due to the intensive usage for analogue TV, digital TV and other services it is difficult to find sufficient frequencies in some locations (e.g. big cities) for large events. In the CEPT draft report it is noted that PMSE demand for spectrum is expected to continue to rise in the medium term and that even if there was no reduction in the quantity of interleaved spectrum available for PMSE, users would eventually face increasing constraints in spectrum supply and the need to change the way that they used it.

The draft report examines the potential for PMSE to continue to use the band 790 – 862 MHz including the use of the centre gap in the proposed FDD band plan. However it is noted that the utility of such a small band with no adjacent available spectrum may be limited for professional PMSE users who may require up to 24 MHz or more of contiguous spectrum for large-scale productions. With regard to the protection of PMSE from Mobile/Fixed Communications Networks, SE42 concluded that with the exception of the upper 1 MHz and the lower 200 kHz of the FDD duplex gap where the required protection distances may be considered prohibitive for certain applications, the operation of radio microphones in the FDD duplex gap would not be hindered by interference from Mobile/Fixed Communication Networks equipment.

In the draft report it is recommended that the "PMSE applications in the 470 – 790 MHz band should primarily be the PMSE applications that require some protection (i.e. "Critical use"). This may be achieved by a "controlled" access to the spectrum and could be achieved by administrations via individual licensing regime (see ECC Rec. 70-03) or by specifying the type of equipments allowed to operate in this band. This could increase the efficiency of the spectrum usage and in most cases would provide sufficient amount of spectrum for average demand and in some cases also for peak demand.

It is also proposed that two kinds of bands could be made available to PMSE in addition to 470 – 790 MHz:

- For "less critical" uses which can tolerate higher interference levels or which can not operate in the band 470 – 790 MHz, frequency bands should be identified without a "controlled" access to the spectrum.
- Where interleaved channels are insufficient for "critical" PMSE uses in the band 470-790 MHz to satisfy peak demand, new frequency bands need to be identified, where "critical" PMSE uses can ensure the protection of services such as broadcasting. This may be achieved by a "controlled" access to this new spectrum.

Bands to be considered could be the VHF band (including 216 – 223 MHz), the L band, 1785-1800 MHz or as noted earlier any available spectrum in 790-862 MHz (e.g. duplex gap). The band 863-865 MHz is already available in most CEPT countries for wireless microphones users who do not require guaranteed interference-free spectrum access and do not wish to obtain a license."

A.3.1.3 Deliverable C – "Report / Recommendation on rearrangement activities for broadcasting services in order to free the sub-band 790 – 862 MHz".

This report will provide guidelines to help administrations to re-channel broadcasting networks to use channels 21 – 60 where necessary and so release channels 61- 69 through bilateral / multilateral agreements. It also covers the situations where additional resources may be required for broadcasting in the UHF band, or where an administration does not wish to make a change because of a neighbouring country wishing to introduce a mobile service or to use additional resources for broadcasting.

The report is scheduled to be finalised at the next meeting of TG4 in September 2009 and it was proposed at the last meeting of TG4 to produce an updated version of the working document based on an intermediate submission deadline of 15 July 2009.

A.3.1.4 Deliverable D – "Report on measurements of protection ratios for the protection of the broadcasting service from the mobile service in order to assist administrations in determining the precise situation in terms of compatibility" .

Draft CEPT Report 33 provides information on the required protection ratios based on actual measurements covering linear and overload operation conditions for ten different DVB-T receivers that were tested against UMTS interference. The report is aimed to assist administrations seeking to protect their broadcasting services in the band 470-790 MHz from interference generated by UMTS services in the band 790-862 MHz. It has been submitted to the June ECC meeting for approval prior to the public consultation phase.

In general the outcome of the work has shown that the protection ratios decrease in value (from -31 to -67 dB for the base station interference and from -5 to -55 dB for the user equipment interference) as the frequency offset increases. However, the protection ratio in the image channel is similar to the one in the third adjacent channel. The overloading threshold shows only small variations with frequency offset. At equal frequency offsets the impact of user equipment interference into DVB-T receiver is considerably higher than the one from the base station, the effect being linked to the use of transmit power control. In particular, the latter increases the required protection ratio by 12-26 dB and decreases the overloading threshold detected by 7-11 dB depending on the frequency offset.

The group that undertook this work in ECC TG4 unanimously endorsed the proposal to establish the development of a new report to address measurements on LTE interference into DVB-T reception. Additional measurements are expected for the September meeting.

B CURRENT STATUS OF DTT LICENSING AND IMPLEMENTATION IN EU COUNTRIES

B.1 Belgium

In Belgium 97% of the population use cable systems to access TV programmes. 60,000 homes are dependent on the terrestrial platform for primary TV viewing and a further 80,000 to 180,000 households access TV using both cable and over the air TV. There are two main public TV networks: VRT operates in the Flemish part of the country and RTBF operates in the French-speaking part of the country These providers initially offered a number of TV and radio channels to their respective communities using a single DTT multiplex in each of the two parts of the country. A much more limited regional network also exists to serve Belgium's small German speaking community.

There have been disputes about the timing of analogue switch-off in Belgium. In the Flemish part of the country the national communications regulator (BIPT) applied to the Supreme Court to declare the Flemish government's switchover decision null and void in March 2008. The dispute centres on the competence and authority to regulate and assign frequency allocations within the country. The government of the French-speaking part of the country approved the digital switchover plan in July 2007. The plan calls for analogue TV to be switched off by November 2011. The plan aims to promote mobile and portable TV in order to provide services that cannot be delivered by cable. After the switchover, commercial broadcasters are expected to gain access to new DTT multiplexes.

In the CEPT Report 22[39], it is stated that Flemish, French and German speaking communities have decided to use the 470 – 862 MHz spectrum for broadcasting applications including the provision of higher number of digital TV channels, mobile and portable TV reception, mobile multimedia broadcasting applications and HDTV. The impact analysis undertaken by Belgium concludes that the idea of an introduction of sub-band for non-broadcast applications will have a significant impact on the existing broadcast services. In particular, it is noted that more allotments are in the plan using channels located in the upper part of the 470 – 862 MHz band.

In the CEPT report, it is stated that a significant re-planning of GE-06 will be needed and this is not acceptable to the communities in Belgium. Belgium has 14 allotments in total, 5 of which can deliver at least 5 multiplexes. If channels 61 – 69 are refarmed, no allotments can deliver more than 3 multiplexes, so there would be a considerable impact on UHF DTT provision in Belgium. .

[39] See CEPT Report 22 (Technical Considerations Regarding Harmonisation Options for the Digital Dividend, published in 1.July.2008 at http://www.erodocdb.dk/docs/doc98/official/pdf/CEPTRep022.pdf

B.2 Denmark

In Denmark, three of the four multiplexes currently being rolled out have been awarded to the Boxer company, which will operate a pay TV service. using some of the spare capacity within the multiplexes

B.3 France

A study conducted by Analysys and Hogan & Hartson[40] examined the most efficient way of using the spectrum released by the digital switchover in France which is expected to take place before the end of November 2011. The study considered two distinct scenarios. In the first scenario (referred to as 'sharing the digital dividend'), it is assumed that the part of the spectrum is allocated to services other than broadcasting (e.g. mobile TV and mobile broadband) and in the second scenario (referred to as 'audiovisual only'), it is assumed that the entire spectrum is allocated to broadcasting service.

The results showed that the first scenario satisfies the quantitative tests set by the French parliament for digital television (i.e. minimum number of multiplexes and minimum population coverage). Therefore, it was concluded that allocating a sub-band of the UHF frequencies to other services ensures more efficient use of the spectrum.

In line with the study results, the French Digital Dividend Commission presented its recommendations to the Prime Minister on the 23rd July 2008. The main recommendations were:

i) By 2012, part of the released spectrum should be used to provide 11 DTT multiplexes providing coverage of 95% of the population and to create 2 multiplexes for the provision of mobile TV covering 80% of the population. 11 DTT multiplexes could allow 40 HD channels under an assumption of 4 channels per multiplex.

ii) The sub-band 790 – 862 MHz (i.e. Channels 61 – 69 inclusive) should be offered to provide national fixed and mobile high speed broadband services.

iii) France should be in favour of harmonising the sub-band 790 – 862 MHz for mobile services in the European Union.

There are between 110 and 130 main high powered transmitters (e.g. Tour Eiffel, Pic du Midi and le Mont Pilot) which cover 80 – 85% of the population. Several thousand (up to 3500) repeaters will also be required with variable coverage and multiplex capacity.

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[40] See http://www.analysysmason.com/PageFiles/4324/Valuation%20of%20the%20digital%20dividend%20in%20France%20(English%20Version).pdf for the Executive Summary in English

CEPT Report 22 states that the lower part of the 470 – 862 MHz band has been used intensively in France. The report notes that one DVB-H network is planned on Channel 55. Furthermore, it is proposed that the use of channels above Channel 60 for fixed / mobile broadband services would be more appropriate as the impact on broadcasting would be limited.

In France to release the 790 – 862 MHz spectrum there is a need to migrate the military systems from the 830 – 862 MHz band. In the past it has been necessary to migrate the military from the 1800 MHz and 2 GHz bands – see Annex C for more details. The cost of the refarming was paid through a refarming fund managed by the ANFR and the Ministry of Defence planned the refarming operation in a five to six year plan. There is still the potential to adopt the same approach for the 830 – 862 MHz band with money being advanced to the military and then having the operators, for example, paying back the fund.

In France, a national coverage plan was evolved that allowed for an initial service based on six multiplexes. The regulator, the Conseil supérieur de l'audiovisuel (CSA) assigned existing broadcasters to these multiplexes, and held contests for access to additional capacity by new entrants. These broadcasters were then required to form or appoint companies to act as multiplex operators. When these entities were created, they were then issued with licences allowing access to the necessary spectrum resources, according to the existing national frequency plan. It may be relevant to note that the capital resources of these companies is small, at around €40k - €60k.

Following the initial award, the detailed composition of the multiplexes has been varied on several occasions by the CSA, and further competitions held for access to capacity. One multiplex ('R5') has also been re-planned as an HD multiplex.

B.4 Germany

In Germany it was claimed by the country's telecommunications industry association (Bitkom) that 95% of German households access TV services via cable and satellite. The telecommunications industry has put pressure on the German States[41] to allow part of the UHF spectrum to be used for other services, for example providing broadband services to rural areas. Trials have also been undertaken for mobile TV (DVB-H) using a single 8 MHz channel (different channels were used in different states).

Inputs into CEPT Report 22 suggested a preference for harmonisation of the upper part of the 470 – 862 MHz band as the impact on the existing DTT would be minimal. It was noted that Channels 61 – 63 and 67 – 69 are currently used by the military but that there may be civilian use in the near future for these channels.

[41] Sixteen state governments (Lander) control and allocate broadcasting spectrum.

It was reported in February 2009 that the German Government is planning to use a large portion of the digital dividend, as part of a larger strategy, to support broadband services[42] and ensure broadband access for all households in Germany by 2010. In June 2009 the Federal Council (Bundesrat), which consists of all the country's regional governments, approved the national government's proposal to use the 800 MHz band for mobile broadband. The spectrum, which will be auctioned, will assist in meeting the target of providing, by 2010, 1 Mbps mobile broadband nationally and, by 2014, 75% coverage at 50 Mbps.

B.5 Ireland

The Irish regulator, ComReg, has released a consultation document entitled "Digital Dividend in Ireland - a new approach to spectrum use in the UHF Band." [43] ComReg is of the view that Ireland's digital dividend can boost the country's economy and therefore wants to optimise the amount of spectrum that is released, taking into account:

- the EC proposal for a harmonised non-mandatory sub-band from channels 61 to 69 for non-broadcasting applications, and
- the requirement under the national legislation to provide 6 DTT multiplexes

The Irish allotments in the GE-06 plan were intended to support 8 layers which will support 8 national multiplexes (64 SD or 32 HD TV programme services). Currently there are four national analogue TV channels but satellite and cable services are widely subscribed and offer a much wider range of channels.

The consultation explored three main digital dividend spectrum proposals:

- Mixed usage of the UHF band by broadcasting and non broadcasting applications
- Use of the channels 61 to 69 for non-broadcasting services on a service and technology neutral basis, and
- Possibility of releasing further spectrum within the channel range 21 to 60 (e.g. channels 36 and 38) on a service and technology neutral basis.

In the case of the additional sub-band it is noted in the consultation that this would require further adjustment of the spectrum reserved for broadcasting and would need to be evaluated on the technical and economic merits. Also decisions made by other administrations would influence the availability of equipment for non broadcasting applications but currently such proposals are unclear except a proposal from the UK to clear a lower sub-band comprising channels 31 to 37 inclusive.

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[42] See http://www.telecompaper.com/news/article.aspx?cid=659108#

[43] See http://www.comreg.ie/_fileupload/publications/ComReg0915.pdf . The Consultation Document was released on 12 March 2009.

BOXER DTT has abandoned its plans to provide digital terrestrial television (DTT) under the contracts it was awarded by the Broadcasting Commission of Ireland (BCI) last July. Its decision to pull out means that a consortium comprising TV3, Eircom and Setanta Sports will be offered the licences for the three commercial DTT multiplexes. The BCI said it has asked the One Vision consortium, the second placed applicant in the licensing competition, if it is still interested in the licences and still in a financial position to offer DTT services in time for the switch-off of analogue services in 2012. See www.irishtimes.com/newspaper/finance/2009/0421/1224245068180.html

B.6 Italy

Italy adopted a National Frequency Assignment Plan for Digital Terrestrial Television in January 2003[44]. It was planned to have three single frequency networks (SFNs), to guarantee national coverage with three frequencies, with the possibility that they be broken down into multi frequency networks (MFNs) of the same size with regional coverage once the transition to digital is completed. Further information on the Italian plan for digital switchover can be found at http://ec.europa.eu/information_society/policy/ecomm/doc/current/broadcasting/switchover/it_digital_sw_it_rev1_en.doc . However it should be noted that the draft timetable for switchover and switch-off has not been achieved and it is currently anticipated that the switch-off date will be 2012 at the latest. The original draft switch-off date, laid down by Law No 66 of 2001 was 31 December 2006. The public broadcaster RAI (Radiotelevisione Italiana Spa) was to provide two multiplexers on digital terrestrial frequencies with a national coverage of:

- 50% of the population by 1 January 2004
- 70% of the population by 1 January 2005
- Complete conversion from analogue to digital in one or more broadcasting catchment areas.

It was reported in a Study by Europe Economics for Irish Regulator ComReg[45] that Italy's communications regulatory authority (Agcom) has allocated the first major portion of the DTT spectrum, on an equal basis, to the 3 main terrestrial broadcasters (RAI, Mediaset and Telecom Italia Media). Also the decisions of Agcom as well as of the Ministry of Telecommunications strongly hint that spectrum available after switchover will be used largely or solely for broadcasting purposes. This ties in with comments that Italy is reluctant to have a common European strategy for the Digital Dividend and spectrum in general[46].

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[44] Resolution No 15/03/CONS of 29 January 2003.

[45] "How Ireland can best benefit from its digital dividend, Europe Economics

[46] Report from Policy Tracker titled: "Regulators chairman campaigns for digital spectrum release" , February 2009.

B.7 The Netherlands

In the Netherlands switchover took place in December 2006. The bandwidth formerly used by analogue TV services has been licensed to KPN until 2017 for digital TV broadcasting. Under its agreement with the government, KPN would build digital broadcasting masts and continue to broadcast state-supported channels and regional public programmes free-of-charge. The rest of the bandwidth would be used to provide digital pay-TV channels.

The Dutch DTT platform offers a combination of free-to-air and pay-TV channels. It is operated by Digitenne (whose parent company is KPN) with several other operators. The current platform offers 23 TV and 17 radio programmes, using 5 multiplexes. The frequencies used in the multiplexes are scattered throughout the UHF band. Channel 38 is used for radio astronomy. Wireless microphones are allowed in Channels 21 – 31, 41 – 60, 63 and 64 – 67. Audio links are allowed in Channels 31 – 41 and 49. Channel 63 will remain dedicated to wireless microphones.

The digital dividend is primarily used to extend the DTT coverage. Prior to the analogue switch off 50% of population had access to DTT services. Digitenne aims to provide indoor DTT coverage throughout the country. Unlike, for example, France and the UK, the transmitter network has been substantially re-modelled at switchover, with a higher density of medium-power sites providing a greater uniformity of field strength for portable use. Single Frequency Networks are generally used. The full DTT network will comprise 45 major transmission sites.

CEPT Report 22 indicated that, as of the second half of 2007, digital TV is available for the entire population for roof-top reception, 70% of population for portable indoor reception and 80% of population for outdoor portable reception.

The CEPT report noted that the harmonisation of the parts of the band IV/V will be constrained as 5 multiplexes are licensed until 2017. It is stated that the current multiplexes use all available frequencies. Some frequencies are not available during the transition phase due to the protection requirements of analogue TV and military use in neighbouring countries. These frequencies are expected to become available in 2012, after which it should be technically possible to release at least part of the 790 – 862 MHz band for other services. It is proposed that the amount of spectrum that could be made available will be limited to 6 x 8 MHz.

B.8 Norway

In the UK regulator Ofcom's recent consultation document on releasing the 790 – 862 MHz band it is mentioned that Norway is considering the release of this band, however there is currently no further information on the English version of the NPT's web-site.

B.9 Slovakia

A consultation on the Digital Dividend closes on the 3rd April 2009 and questions posed include[47]:

- Use of 790 – 862 MHz for mobile broadband services
- Number of DVB-T multiplex to be available nationwide
- Technology to be used for the mobile multimedia services

B.10 Spain

As noted earlier the release of the upper portion of 470 – 862 MHz is likely to be extremely difficult due the widespread use of these channels for digital TV in Spain. Spain's reservations about the harmonisation proposal, noted in CEPT Report 22, stated that the release of channels 62 – 69 is the worst of the four release options originally considered for Spain. After switchover new multiplexes will be allocated and Spain had indicated that 5 layers would need to be allocated to DVB-T in the channel 61 – 69 range taking into account that 7 multiplex are already operational. Also all the existing Digital Terrestrial TV layers are located in the upper part of the spectrum and this includes 4 nationwide SFN multiplex in the channels 66, 67, 68 and 69.

In Spain[48] the law requires that all existing analogue TV services receive a DTT licence. In many cases these broadcasters have been allocated two digital service slots, accounting for the large number of national coverage layers (12) compared to other European countries. The Multiplex Operators are not regulated under Spanish law. The public broadcaster RTVE will be allocated 2 DTT multiplexes after analogue switch off in 2010 and the commercial broadcasters Antenna 3, Cuatro, la Sexta, Veo TV and Net TV will each be allocated a full multiplex.

In March 2009 it was reported in El Pais that the new Government had proposed to amend the General Broadcasting Law to allow Broadcasters to lease or sell up to half their total licences five years after they have been allotted. The proposal goes on to extend the licence period from 10 to 15 years and makes the proviso that if broadcasters fail or stop broadcasting for a period of one year that their licence will be revoked. The proposed legislation was at that time in preparatory status with Parliament.

Pay DTT services are not currently available and the Spanish Government announced in September 2008 that the introduction of legislation to introduce pay DTT services would require the consensus of all the broadcasters. In April 2009 the Government announced that Spanish TV channels could apply for operator licences immediately but the concession to broadcast Pay TV signals was still

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[47] See : http://www.teleoff.gov.sk/index.php?ID=1501

[48] Main source of information http://www.dvb.org/about_dvb/dvb_worldwide/spain/

conditional on the Spanish cabinet approving a report from its advisory council known as El Consejo del Estado.

Most recently in June 2009 the Minister of Industry announced that there would be a digital dividend[49] and that the 790 – 862 MHz band would be reserved for services other than TV "like mobile broadband services". Analogue switch off is planned for 2010 and broadcasting will be allowed in the current bands for a further four years so the mobile operators will have to wait until 2015 before they gain access to the spectrum. It was announced that the digital dividend will contribute to economic growth, new jobs creation and increased productivity and that the European Commission had estimated the incremental value of the use of the dividend in Spain at €12.billion to €16 billion, the equivalent to 1.5 % of GDP".

B.11 Sweden

The allocation of the digital dividend has been completed in Sweden and spectrum between 790 and 862 MHz will be auctioned and allocated for other services. The remaining UHF spectrum will support a minimum of 6 multiplexes. Digital switchover was completed in October 2007.

The broadcasters had initially requested access to the entire UHF band to allow for the migration of the DTT platform from MPEG-2 to MPEG-4 AVC compression format, along with the possible transition to DVB-T2. The availability of HD services is expected to be important as other platforms (cable, satellite and IPTV) are increasingly offering HD services.

In July 2008 it was reported[50] that DTT services were currently available from five nationwide multiplexes that ranged in population coverage from between 70% and 99.8%. A sixth multiplex was due to provide services by the end of 2008 and there was a seventh regional multiplex for the capital city, Stockholm. The broadcast regulator, RTVV, had licensed ten TV programme services using MPEG4-AVC and was hoping to encourage the adoption of this format for all DTT services.

In Sweden[51] the precise channel-by-channel make-up of the Multiplexes is determined by the Government and the Radio and TV Authority (RTVV). The RTVV grants broadcasting (content) licences for all television broadcasts except Public Service and there is no licence required for the multiplex operators. Rules for the application procedures and related fees are issued by the RTVV. In March 2008 40 national coverage licences were issued and 14 local and regional licences. There were 5 transmitter networks using MPEG-2 compression and a sixth was planned for 2009 using MPEG-4. The applications for these licences had to include information on the ownership, financial and technical information, planned broadcast

[49] Reported in Policy Tracker on June 17th 2009

[50] DigiTAG Web Letter

[51] See http://www.epra.org/content/english/press/papers/Dublin/Wg3_sweden.pdf

area and hours, a declaration regarding programming and a description of planned technical cooperation with other licence holders. The application fee was SEK 30,000 (€2,750) per service. The applicants were considered on the basis of their financial status, business plan technical capability in terms of operating a broadcasting enterprise, willingness to cooperate with other licensees concerning technical matters to ensure that basic joint functionality works and the range of programmes. Normally a single company would not be able to use an entire Multiplex. Local and regional programmes are given preference. The licence holders had to come to an agreement with a Multiplex Operator and currently Boxer is the only one. Teracom, the broadcast network operator, owns 100% of Boxer

B.12 Switzerland

Switzerland has already made the transition to DTT and digital switch-over was completed in 2008. It has been decided to allocate the 790 – 862 MHz band to mobile broadband. The Swiss government said use of this spectrum will enable excellent mobile broadband coverage of rural areas while offering good penetration into buildings. As radio waves travel long distances in the low-frequency bands, using this spectrum enables operators to provide mobile broadband coverage far more cost-effectively than in the high frequency bands.

B.13 Turkey

Turkey has indicated its support for the harmonisation of the upper band of 470 – 862 MHz[52]. In April 2007 it was announced by the Anten Corp that Digital TV broadcasting would begin in 13 major Turkish cities within the next six months and then gradually be extended to other areas. Anten Corp was established to unite TV transmitter operations and the Executive Board is comprised of members from Transportation Ministry, national public broadcaster TRT and the private broadcasters Kanal D, Show TV, ATV, Star TV, NTV, Kanal 7 and STV

B.14 UK

The UK was the first country in Europe to plan specifically for the release of a digital dividend on completion of digital switchover. In 2003 the regulator announced plans to release a smaller, upper band of 48 MHz in the range 806-854 MHz (channels 63-68); and a larger, lower band of 64 MHz between 550 MHz and 630 MHz (channels 31-35, 37 and 39-40). This was prior to any moves at European level to harmonise the digital dividend. However, in the recent consultation Ofcom[53] is proposing to clear Channels 61 and 62, which were originally planned for DTT and Channel 69 which is used for PMSE (including radio microphones) to align the

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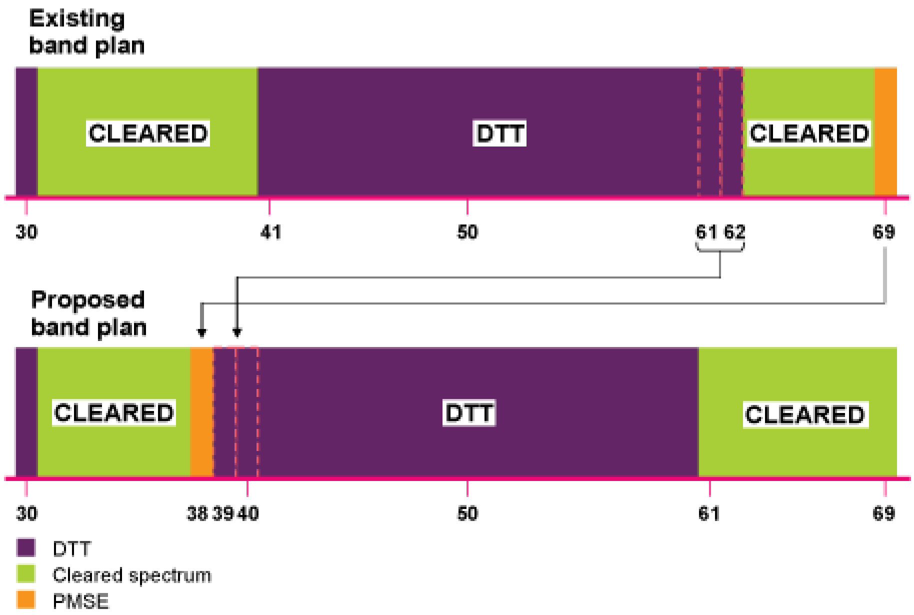
[52] CEPT Report 22, Annex A6

[53] See http://www.ofcom.org.uk/consult/condocs/800mhz/800mhz.pdf

upper digital dividend band with CEPT's harmonised band. As a consequence, Ofcom has proposed that PMSE use should migrate from channel 69 to channel 38.

Figure B-1 Comparison of previous and proposed band plans



Currently approximately 1,700 users are licensed to use channel 69 in the UK and these account for most wireless microphone users. Wireless-microphone users in the UK place great value on channel 69 because it is adjacent to interleaved spectrum in channels 67 and 68 which are currently used for analogue terrestrial television but not heavily so. This means they afford microphone users access to the 24 MHz in channels 67-69 on a near-UK-wide basis. It was therefore important to identify alternative spectrum and a number of different options were considered:

- Interleaved spectrum. There are technical similarities with Ch 69 and availability of equipment across the UK. The main concern was that with more intensive use of the lower channels it may become more difficult to find suitable interleaved spectrum for PMSE.
- Channel 38. This can provide 8 MHz of spectrum on a UK-wide basis and will be next to interleaved spectrum in and above channels 39 and 40 so is very similar to Ch 69.
- FDD duplex split. The possibility of using the 12 MHz centre gap between the down and up links of the mobile sub-band is under consideration and is it would need to be used by low power devices it would be suitable for wireless microphones. If this approach is adopted across much of Europe it could offer economies of scale. The issue is when it would be possible to start using this spectrum.
- Channel 70 (862 – 870 MHz). This has been identified for greater licence – exempt use and would not be suitable for professional requirements.

- 1785 – 1800 MHz. This spectrum is allocated to digital wireless microphones but not currently used.

Ofcom has consulted on Channel 38 which they consider to be the preferred option technically, economically and on the basis of coverage.

This proposed solution will reduce the amount of spectrum that can be cleared in the lower part of the band (now channels 31 - 37). In the Ofcom consultation it is mentioned that identifying harmonised spectrum in the lower bands is likely to be very difficult.

In the UK the Multiplex licences were originally awarded in 1996. Two of the six available were reserved for the existing public service broadcasters (BBC and ITV). The selection criteria for the other Multiplex Operators were based on coverage, speed of roll-out, ability to establish and maintain services, appeal / range of programme services, plans to assist viewers to acquire decoders and plans to ensure fair and competitive competition with providers of programmes and services. There was a separate process for the licensing of the broadcasters and this was on the basis of a guaranteed amount of multiplex capacity rather than the assignment of specific frequencies.

Three of the six Multiplexes have been awarded to the Transmission company Arqiva[54] and, although some of the programme channels carried are specified in the licence they have also been free to create more space on their multiplexes by better compression techniques, and to auction this “new” space for further programme channels.

[54] Actually awarded to Crown Castle, which became National Grid Wireless, which was later absorbed by Arqiva.

C REFARMING OF FRENCH MILITARY 2 GHZ BANDS

C.1 Overview of Process

The 2 GHz refarming process is the terminology that ANFR used to describe the migration of the military from bands between 1700 MHz to 2.4 GHz. The refarming of the French military bands began in 1991 before ANFR was created. A general agreement was reached in 1991, after long inter-Ministerial discussions, between the Ministry of Defence and the Telecom Ministerial Office on a general band exchange to free the 1710 – 2100 MHz frequency bands which had been designated, within Europe, for DCS 1800 (GSM). The band had been heavily used[55] by each of the three military services for their national infrastructure networks (fixed services) and to a lesser extent for other mobile services.

In 1992 new laws were passed in France that permitted the start of deregulation and between 1991 and 1995 two operators provided services over GSM 900 spectrum. At the end of 1994 additional spectrum was required in the 1800 MHz band to allow the entry of new mobile operators. Before 1994 refarming of the spectrum had been done by the Ministry of Defence with its own funds but it was taking a long time, was not on a large scale and not suitable to meet the new requirements.

In mid 1995, with the support of the Telecom Ministerial Office, discussions between the first DCS 1800 operator, Bouygues Telecom, and the Ministry of Defence began. The key issues were:

- The cost of refarming
- Compatibility between the new mobile networks and the military fixed services
- How to handle the complexity of refarming at the same time as changes in the geographical military organisation
- Timing.

At the end of 1996 there was a first agreement with Bouygues Telecom which covered the first part of the refarming process. The agreement covered the geographical areas, organised the move of the links, and set out the geographical constraints to protect fixed links in other areas from potential interference. Bouygues Telecom paid the Ministry of Defence directly through the refarming fund. Other agreements were set up for further phases of the refarming exercise.

At the end of 1997, following the establishment of the ANFR, the two GSM 900 operators requested more frequencies and it was decided to complete the refarming of the DCS 1800 frequency band. At the same time The Ministry of Defence recognised the difficulties of refarming not only the DCS 1800 spectrum but also the

[55] In the fixed service band of 1700 – 2700 MHz the military had 1500 links (3,000 sites) of which 25% were in the lower part of the band.

UMTS spectrum within the necessary timescales and decided to plan the whole 2 GHz refarming operation in a five or six year plan. The plan was proposed to ANFR with a request for financial support from the refarming fund. The process of refarming is expected to continue until the beginning of 2004.

C.2 Key issues during the process of refarming the 2GHz band

The Ministry of Defence had to solve a number of issues as identified previously; how to estimate costs, compatibility issues of sharing spectrum during the migration, complexity of the process and the time planning.

Costs:

The Ministry of Defence could not just move their fixed links from their current frequencies to adjacent bands because of the need to migrate from the 1800 MHz, 2 GHz and 2.4 GHz bands. It was therefore necessary to use higher frequency bands and new equipment. The next issue was the availability of suitable equipment and whether it was possible to use modified fixed service equipment designed for the civil markets. Slight modifications were specified and implemented to equipment that operates in the available civil bands.

Costs of refarming were initially calculated on the basis of the cost of military equipment in the 2 GHz band, reduced by a depreciation factor plus the necessary funds to purchase upgraded civil equipment for use in higher frequency bands. After 1997, under ANFR supervision, the costs have been significantly reduced by looking at the requirements on a national level over a six year period. Large procurement contracts were put in place following a long open competition. The costs of personnel and the different studies carried out by the Ministry of Defence on technology and compatibility issues were not included in the refarming costs.

Compatibility:

The refarming process was extremely complex as it was necessary to:

- Harmonise the military fixed services network into a new Defence national network
- Transfer a lot of links on to optic fibre
- Reduce the geographical extension of the network to match with reduction in the military forces
- Consider compatibility constraints for a number of potential configurations.

Timing:

Bouygues Telecom achieved a fast roll-out and needed to gain access to spectrum, mainly in the geographic areas of Paris, Lyon and Cote d'Azur, before the Ministry of Defence fixed links could be removed from the band. It was therefore necessary to change plans and the solution was for the military links to move frequencies within the same band. This was not a simple exercise as the masts, antennas, and geographical structure of the networks had to be studied and modified as necessary. It was not possible to handle all the moves in one year as procurement had to be planned.

D COMPRESSION FORMAT DEPLOYED OR PLANNED

The table below is from the DigiTAG (Digital Terrestrial Television Action Group http://www.digitag.org/) . It is interesting to note that the majority of the countries with a planned later Analogue Switch Over (ASO) date are intending to use MPEG-4 compression format which will support HDTV.

Table D-1 Compression formats and analogue switchover plans in Europe and neighbouring countries

Country	Launch date	Compression format	Completion of ASO
UK	1998	MPEG-2	2012
Sweden	1999	MPEG-2	Completed
Spain	2000 / 2005	MPEG-2	2010
Finland	2001	MPEG-2	Completed
Switzerland	2001	MPEG-2	Completed
Germany	2002	MPEG-2	Completed
Belgium (Flemish)	2002	MPEG-2	Completed
Netherlands	2003	MPEG-2	Completed
Italy	2004	MPEG-2	2012
France	2005	MPEG-2 / MPEG-4 AVC	2011
Czech Republic	2006	MPEG-2	2011
Denmark	2006	MPEG-2 / MPEG-4 AVC	2009
Estonia	2006	MPEG-4 AVC	2010
Austria	2006	MPEG-2	2010
Slovenia	2006	MPEG-4 AVC	2010
Norway	2007	MPEG-4 AVC	2009
Lithuania	2008	MPEG-4 AVC	2012
Hungary	2008	MPEG-4 AVC	2011
Ukraine	2008	MPEG-4 AVC	2014
Portugal	2009	MPEG-4 AVC	2012

Country	Launch date	Compression format	Completion of ASO
Ireland	2009	MPEG-4 AVC	2012
Russia	TBC	MPEG-4 AVC	2015
Slovakia	2009	MPEG-4 AVC (expected)	2012
Poland	2009	MPEG-4 AVC (expected)	2014

The following table provides further details on some countries. It should be noted that although at switch-over the choice was MPEG-2 in some countries, such as Sweden, there are plans to migrate to MPEG-4.

Table D-2 Further information on compression formats

Country	Compression
Austria	Believe ORF-1 planning to utilise MPEG-4 for HDTV [56]
Bulgaria	Bulgaria launched a free-to-air platform on Sofia region, starting in November 2004. Standards chosen are DVB-T/DVB-T2 and MPEG4/H.264 compression format[57].
Croatia	MPEG-4 AVC stipulated in recent tender for 2 DTT multiplexes[58].
Denmark	Boxer's Pay TV services use MPEG-4. Public channels use MPEG-2. Radio and television board called for all 4 multiplexes to eventually use MPEG-4 AVC compression and multiplex 1 must change to MPEG-4 by 2012.
Estonia	The pay-DTT platform ZUUMtv is set to become fully owned by cable operator Starman. It had previously been jointly owned by Starman and the network operator Levira. The DTT platform uses the MPEG-4 AVC compression format[59].

[56] See http://tech.ebu.ch/docs/techreview/trev_2009-Q1_HD-ORF.pdf

[57] Wikipedia http://en.wikipedia.org/wiki/Digital_terrestrial_television

[58] DigiTag news 31 March 2009.

[59] DigiTag news, 4 July 2008.

Country	Compression
Finland	The sixth multiplex will offer services using the MPEG-4 AVC compression format.[60]
France	MPEG-2 for free to air and MPEG-4 for pay TV channels.
Germany	RTL announced that they would launch DTT services in Stuttgart using the MPEG-4 AVC compression format with HD services becoming available in 2012.[61]
Hungary	MPEG-4 AVC following comprehensive trials to allow for HDTV
Luxembourg	Broadcasting Centre Europe (BCE). It has been commissioned to investigate the feasibility of broadcasting a Luxembourgish multiplex in MPEG-4, which would allow for the broadcasting of HD programmes in the future.
The Netherlands	Reports from vendors that deploying MPEG-4 e.g. "In the Netherlands, UPC has just started a large-scale rollout of digital TV in which it will invest €300 million. By making this investment UPC wants to turn digital TV into a mass product in the Netherlands. Philips will introduce its HDTV DCR7000 Euro-DOCSIS set-top box to UPC customers. This will decode MPEG-4 HDTV streams from UPC to offer viewers a full interactive digital TV experience."
Norway	MPEG-4
Slovakia	The Slovak Telecom Office (TU SR) recommended the use of the MPEG-4 AVC compression format for the DTT platform[62].
Sweden	DTT operator Boxer is to begin the deployment[63] of MPEG-4 receivers to new subscribers Over next 6 years will migrate from MPEG-2 visual coding to MPEG-4, H.264.
UK	OFCOM has opted for MPEG-4 AVC level 4.0 for HD services on the terrestrial platform. DVB-T2 will be used for the transmission. This decision will result in viewers accessing HD services in either 1080i or 720p HD formats rather than in 1080p. HD services are currently broadcast in

[60] DigiTag http://www.digitag.org/DTTMaps/country_homePage.php# 30.03.08

[61] DigiTAG http://www.digitag.org/DTTMaps/country_homePage.php# 19.02.09

[62] Broadband TV News, July 2008. http://www.broadbandtvnews.com/?p=5469

[63] Broadband TV news 1.04.2008

Country	Compression
	1080i and 720p while 1080p is only used in Blu-ray discs. OFCOM noted that the selection of the more advanced compression format could have delayed the availability of DVB-T2 products on the market since manufacturers would feel compelled to make the products 1080p50-compatible. It would also have increased the price of the receivers[64].

1. Sources of information: Country data from DigiTAG web site: http://www.digitag.org/DTTMaps/country_homePage.php# and DVB.org and Broadband TV news.

[64] Source DigiTag http://www.digitag.org/DTTMaps/country_homePage.php# 12.02.09

E IMPACT OF CHANGES IN TECHNOLOGIES

There have been a number of studies undertaken to aid understanding of the impact that a change in the mode of digital terrestrial television (DTT) signal may have on the coverage of services. For example in the UK as early as May 2002 a study[65] was undertaken that considered the impact of changing from modulation mode 64 QAM R =2/3 to 64 QAM R=1/3, 16 QAM R=3/4 or 16QAM R=2/3 assuming the network of multiplexes and broadcast sites remained unchanged. The reason to alter the modulation mode is to alter how much data a single carrier can carry noting of course that the more information carried by a carrier the more susceptible that carrier will be to noise and interference. 16 QAM can potentially support 25.2 Mbit/s and 64 QAM 37.8 Mbit/s so the capacity could be increased by approximately 33%[66]. The digital signal is protected against interference by using error protection codes and this determines the amount of the available capacity is used to detect and correct errors that the signal may suffer from interference or noise. Codings rates can be R=1/2, 2/3, 3/4, 5/6 or 7/8 and the number refers to the proportion of data that is used for the wanted information. In the report there is a summary of the different modes considered which is replicated below:

Table E-1 Modulation and Coding Schemes

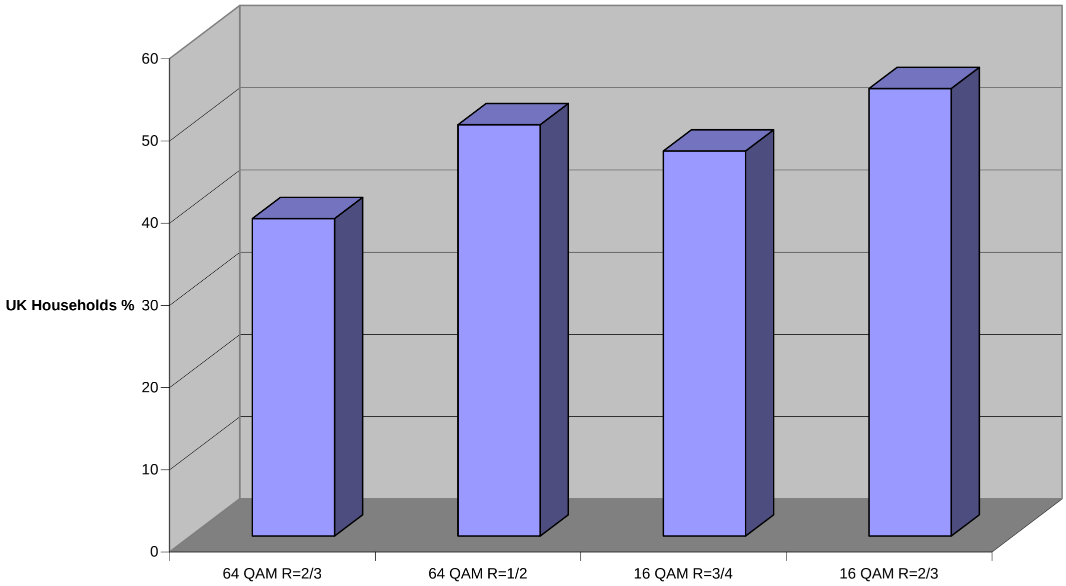
Modulation	Coding	Net data capacity	Robustness	Comments
64 QAM	2/3	24 Mbit/s	Low	Can carry up to 6 TV services
64 QAM	1/2	18 Mbit/s	Medium	Capable of carrying up to 4 TV services
16 QAM	3/4	18 Mbit/s	Medium	Capable of carrying up to 4 TV services
16QAM	2/3	16 Mbit/s	High	Capable of carrying 3 TV services, possibly 4

The figure below replicates the results of the reception coverage (percentage of UK households) that would be achieved using the core six multiplexes.

[65] "DTT Coverage: Impact of existing installations & mode changes on reception Coverage" , Digital Television Action Plan Spectrum Planning Group.

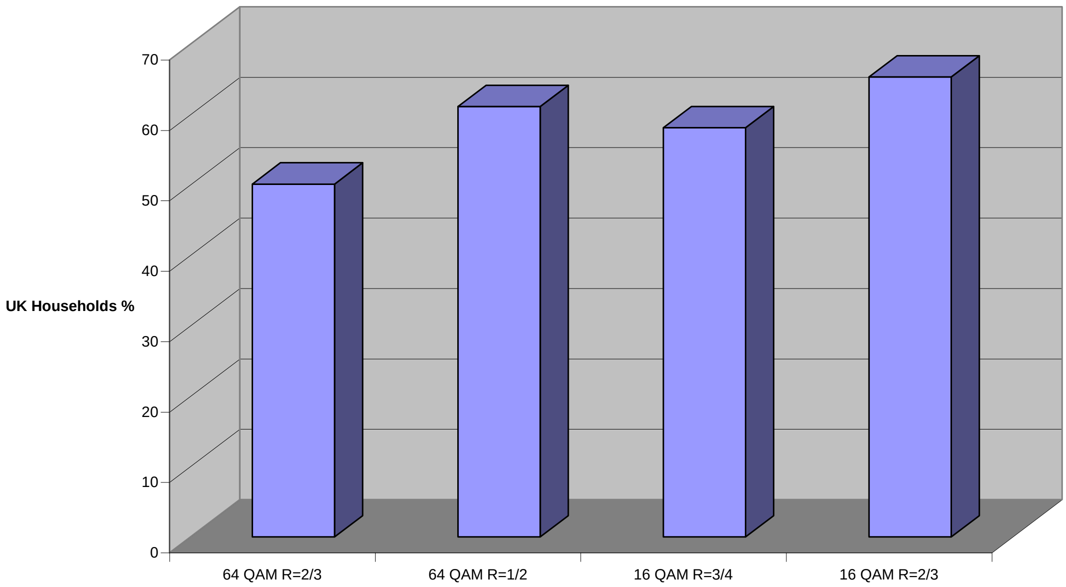
[66] It should be noted that moving to MPEG-4 the capacity could be increased by around 100% with no coverage penalty.

Figure E-1 Reception coverage in the UK



It is of course not necessarily the case that the coverage reception in Greece would vary similarly as much depends on the location of the transmitter sites and the coverage reduction of moving to 64 QAM would need to be checked for each site using a suitable planning tool. In the UK the impact of increasing the power by 3 dB was also considered and the figure below shows the increase in reception coverage predictions.

Figure E-2 Reception coverage in the UK with 3dB increase in power



Of course whether the power could be increased by 3 dB in Greece would depend on whether it would be feasible and a key consideration would be international interference. Another option would be to deploy in-fill low power transmitters if it is not feasible to increase the power.

F POSSIBLE USES OF THE DUPLEX GAP IN THE 790 – 862 MHZ BAND

F.1 Introduction

It has been proposed in Section 5.10.2 that there might be the potential for the MoD to utilise the duplex gap, which may be either 10 or 12 MHz in total, in the 790 – 862 MHz band between the FDD downlink and uplinks proposed for harmonisation for electronic communications networks including LTE. The feasibility will depend on:

- the technical characteristics of the tactical radio links,
- the required bandwidth to support the number of links that are deployed in any given geographic area, and
- the ability to achieve geographic separation.

However it should be noted that there have been proposals within work ongoing in CEPT to utilise the duplex gap for PMSE and that might lead to conflicting demands for the same spectrum.

In this Annex we have summarised:

- the outcome of the studies to date considering utilising PMSE in the duplex gap and also
- a study[67] undertaken in 2004 that considered the compatibility between wideband PMR and Tactical Radio Relay (TRR) links in the 870 – 876 MHz / 915 – 921 MHz band which provides a useful insight into whether it will be possible to facilitate sharing between electronic communications network (ECN) and Tactical Radio Relay links.

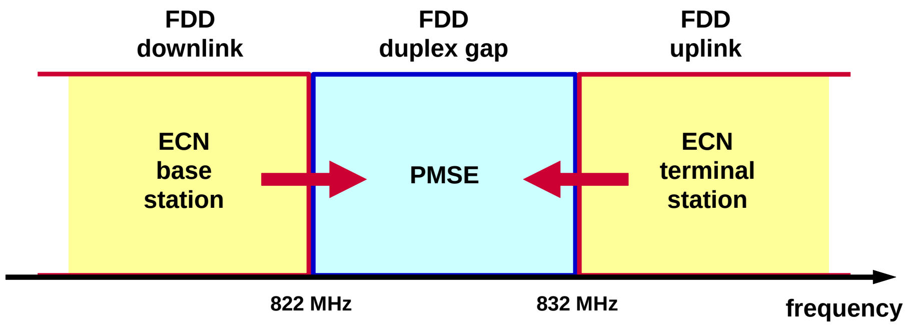
Finally we consider what might be the outcome for sharing between ECN and TRR.

F.2 Potential for PMSE to utilise duplex gap

The figure below shows the sharing considerations between FDD electronic communications network (ECN) equipment and PMSE equipment.

[67] ECC Report 58, "Compatibility between TETRA Release 2 TAPS and Tactical Radio Relays in the 870 – 876 and 915 – 921 MHz bands.

Figure F-1 Interference from ECN into PMSE (Radio Microphones)



It is assumed that the ECN equipment will be LTE and assumes that the interferer base station (BS) radiates at an in-block EIRP of 64 dBm/(10 MHz).

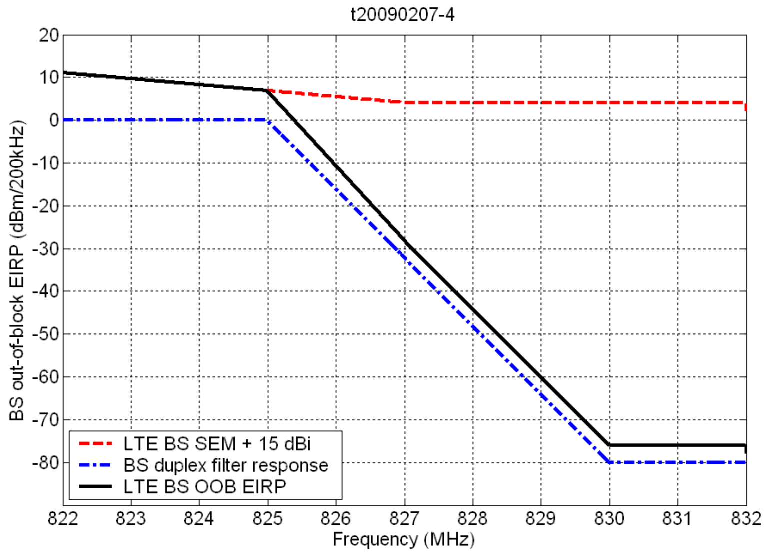
In the case of interference between the BS transmitter and the radio microphone it was assumed that a protection distance was required that could ensure that radio microphone met a minimum signal-to-interference-plus noise (SINR) ratio of 20 dB.

The following conclusions were drawn from the results of this part of the study:

- For the radio microphone operating in the lowest 200 kHz channel of the duplex gap, and given a BS out-of-block EIRP of 10 dBm/(200 kHz), the BS-RM protection distances are typically below 200 m.
- Within the remaining 200 kHz channels of the duplex gap, and given a BS out-of-block EIRP of 10 dBm/(200 kHz), the BS-RM protection distances are below 100 m.

It was further shown that, where the interferer BS radiates with an out-of-block EIRP which complies with the LTE BS Spectrum Emission Mask (SEM) for a 10 MHz bandwidth and is subject to duplex filtering as shown in the figure below then the protection distance between the BS and the radio microphone is typically much smaller than 100 m.

Figure F-2 Assumed BS emission mask for an antenna gain of 15 dBi



The following conclusions were drawn re sharing between a LTE terminal and a radio Microphone utilised outside a building:

- Within the highest 1 MHz of the FDD duplex gap, the required TS-Radio Microphone protection distance is 90-94% of the separation between the Radio Microphone transmitter and Radio Microphone receiver;
- Within the remaining portions of the FDD duplex gap, the required TS-Radio Microphone protection distance is less than 40% of the separation between the Radio Microphone transmitter and Radio Microphone receiver;

In summary it was concluded “that, with the exception of the upper 1 MHz and the lower 200 kHz of the FDD duplex gap where the required protection distances may be considered prohibitive for certain applications, the operation of radio microphones in the FDD duplex gap would generally not be constrained as a result of interference from ECN equipment.”

F.3 Compatibility between TETRA release 2 TAPS and Tactical Radio Relay links in the 870-876 and 915-921 MHz bands

This is probably the closest study that is comparable to sharing between ECNs and tactical radio relays (TRR). It examined the sharing potential between wideband PMR (TETRA release 2 TAPS) and conventional Military Tactical Radio Relay links in two different scenarios; co-channel and adjacent channel[68].

It was found that using the MCL (minimum coupling loss) method the potential of interference exists at very large distances when the frequency used is shared and

[68] ECC Report 58: “Compatibility between TETRA Release 2 TAPS and Tactical Radio Relays in the 870 – 876 and 915 – 921 MHz bands

no mitigation techniques are applied. As we are proposing that ECNs and tactical radio relay should operate in adjacent channels we have summarised the outcome below.

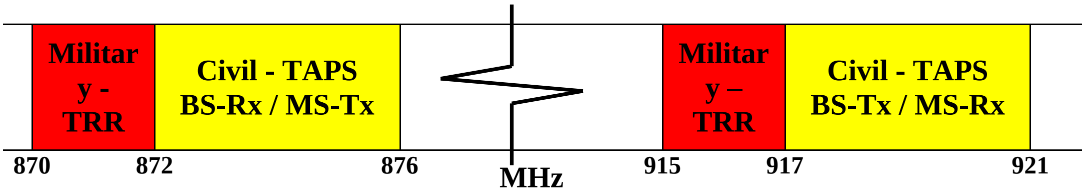
The report used technical parameters available from the relevant standards combined with realistic deployment scenarios. Two TRR equipment types were considered:

- STANAG 4212, NATO standard
- Eurocom, STANAG 4212 enhanced with Unwanted Emissions and Blocking characteristics of AN/GRC-245, Eurocom radio equipment.

The Eurocom deployment was also considered as it is more spectrally efficient than the STANAG 4212 deployment.

The adjacent channel study considered the scenario below:

Figure F-3 Tactical radio links sharing with wideband PMR (TETRA TAPS) (Source ECC Report 58)



Two complementary methods (SEAMCAT and MCL) were used in the study to:

- Define the necessary geographic separation if systems would operate within distinctly separate geographical areas
- Define the necessary frequency separation if the systems are co-located in the same area.

The four interference scenarios considered were:

- TAPS-MS into TRR around 872 MHz
- TRR into TAPS-BS around 872 MHz
- TAPS-BS into TRR around 917 MHz
- TRR into TAPS-MS around 917 MHz

F.3.1 Outcome of SEAMCAT Modelling

In all the SEAMCAT modelling of the four interference scenarios the TAPS system was deployed in an *urban environment* while the environment of the TRR system was varied. The guard band necessary to facilitate co-existence was calculated and the figure below is an illustration of the frequency separation considered for the TAPS uplink band, which was mirrored in the TAPS downlink band. As can be seen the frequency separation (guard band) is calculated from the channel edges of the two adjacent band systems.

Figure F-4 Guard band necessary to allow co-existence between TRR and TAPS (Source ECC Report 58)

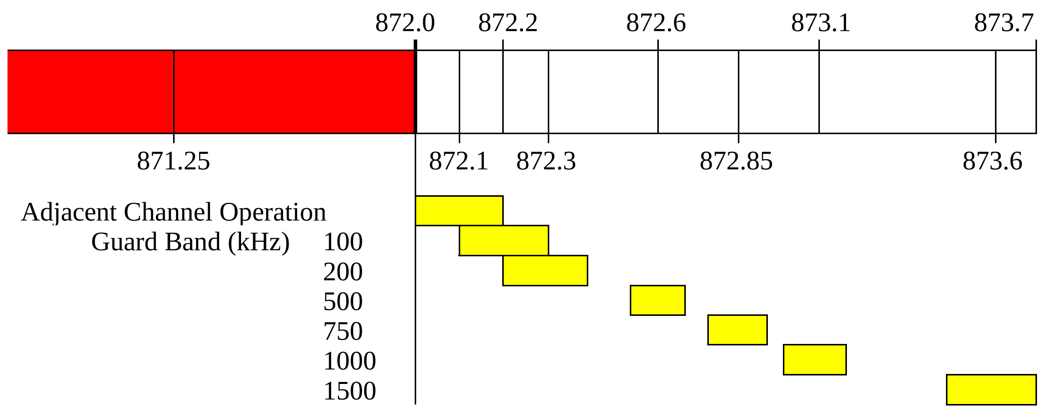
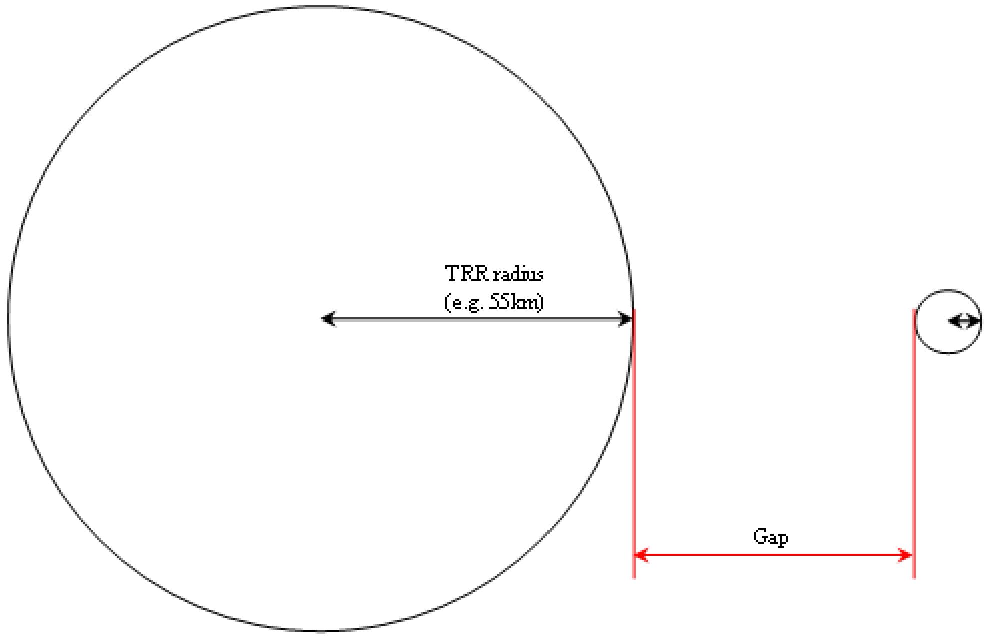


Figure F-5 Geographical separation of systems (Gap)- TAPS radius 2 kms, TRR radius 55 kms (Source ECC Report 58)



In the case of TRR the Active Interference Densities (AID) were estimated to be 40 links for the Eurocom equipment and 15 links for the STANAG 4212 equipment assuming a TRR operating area based on a radius of 55 km and an available bandwidth of 6 MHz.

Table F-1 Probability of interference from TAPS-MS into TRR around 872 MHz for different frequency separations and maximum and average Active Interference densities (AID) of TAPS in urban environment (Source ECC Report 58)

Guard Band (kHz) ⇨ / TAPS AID (1/km²) ⇩		100	200	500	750	1000	1500
	TRR Environment Urban						
STANAG 4212	0.5	84.31%	73.77%	33.66%	12.83%	5.09%	2.92%
	0.1	55.04%	40.71%	10.85%	2.97%	**1.08%**	**0.61%**
EUROCOM	0.5	10.55%	7.32%	3.76%	2.87%	2.36%	**1.73%**
	0.1	2.38%	**1.46%**	**0.78%**	**0.58%**	**0.49%**	**0.29%**
	TRR Environment Suburban						
STANAG 4212	0.5	61.31%	46.85%	14.73%	4.64%	**1.80%**	**0.99%**
	0.1	29.33%	18.85%	3.39%	**0.90%**	**0.35%**	**0.20%**
EUROCOM	0.5	3.73%	2.42%	**1.29%**	**0.98%**	**0.78%**	**0.53%**
	0.1	**0.78%**	**0.53%**	**0.21%**	**0.20%**	**0.15%**	**0.11%**
	TRR Environment Rural						
STANAG 4212	0.5	18.50%	10.73%	2.08%	**0.55%**	**0.19%**	**0.08%**
	0.1	4.79%	2.52%	**0.44%**	**0.10%**	**0.02%**	**0.04%**
EUROCOM	0.5	**0.46%**	**0.31%**	**0.16%**	**0.14%**	**0.08%**	**0.05%**
	0.1	**0.08%**	**0.06%**	**0.04%**	**0.03%**	**0.02%**	**0.01%**

Table F-2 Probability of interference from TRR into TAPS-BS around 872 MHz (Source ECC Report 58)

Guard Band (kHz) ⇨ / TRR AID (1/km²) ⇩		100	200	500	750	1000	1500
	TRR Environment Urban						
STANAG 4212	0.0075	17.44%	7.83%	**0.55%**	**0.15%**	**0.17%**	**0.14%**
	0.0015	3.82%	**1.75%**	**0.10%**	**0.04%**	**0.03%**	**0.01%**
EUROCOM	0.0075	9.02%	7.88%	**0.86%**	**0.50%**	**0.52%**	**0.46%**
	0.0040	4.80%	4.27%	**0.39%**	**0.27%**	**0.24%**	**0.27%**
	TRR Environment Suburban						
STANAG 4212	0.0075	17.19%	7.77%	**0.50%**	**0.16%**	**0.11%**	**0.12%**
	0.0015	4.03%	**1.56%**	**0.09%**	**0.03%**	**0.01%**	**0.02%**
EUROCOM	0.0075	8.98%	7.83%	**0.87%**	**0.54%**	**0.54%**	**0.46%**
	0.0040	4.70%	4.33%	**0.53%**	**0.33%**	**0.30%**	**0.32%**
	TRR Environment Rural						
STANAG 4212	0.0075	17.48%	7.73%	**0.51%**	**0.11%**	**0.12%**	**0.13%**
	0.0015	4.18%	**1.73%**	**0.08%**	**0.02%**	**0.02%**	**0.02%**
EUROCOM	0.0075	8.66%	7.78%	**0.90%**	**0.46%**	**0.57%**	**0.49%**
	0.0040	4.82%	4.30%	**0.46%**	**0.31%**	**0.21%**	**0.29%**

Table F-3 Probability of interference from TAPS-BS into TRR around 917 MHz (Source ECC Report 58)

Guard Band (kHz) ⇨	100	200	500	750	1000	1500
	TRR Environment Urban					
STANAG 4212	99.04%	97.69%	86.19%	65.50%	43.12%	28.46%
EUROCOM	62.52%	54.17%	34.22%	26.54%	23.56%	20.86%
	TRR Environment Suburban					
STANAG 4212	95.80%	91.77%	69.86%	44.00%	23.68%	13.43%
EUROCOM	41.12%	32.45%	16.90%	12.27%	10.34%	8.98%
	TRR Environment Rural					
STANAG 4212	74.67%	63.74%	31.32%	12.61%	4.23%	**1.93%**
EUROCOM	11.18%	7.52%	2.60%	**1.64%**	**1.47%**	**1.12%**

Table F-4 Probability of interference from TRR into TAPS-MS around 917 MHz (Source ECC Report 58)

Guard Band (kHz) ⇨	TRR AID ($1/km^2$) ⇩	100	200	500	750	1000	1500
		TRR Environment Urban					
STANAG 4212	0.0075	**0.06%**	**0.03%**	**0.02%**	**0.00%**	**0.01%**	**0.00%**
	0.0015	**0.01%**	**0.00%**	**0.01%**	**0.00%**	**0.00%**	**0.00%**
EUROCOM	0.0075	**0.03%**	**0.03%**	**0.02%**	**0.01%**	**0.00%**	**0.00%**
	0.0040	**0.00%**	**0.00%**	**0.01%**	**0.03%**	**0.01%**	**0.00%**
		TRR Environment Suburban					
STANAG 4212	0.0075	**0.06%**	**0.03%**	**0.00%**	**0.00%**	**0.00%**	**0.01%**
	0.0015	**0.00%**	**0.01%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**
EUROCOM	0.0075	**0.04%**	**0.01%**	**0.01%**	**0.00%**	**0.01%**	**0.00%**
	0.0040	**0.01%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.01%**
		TRR Environment Rural					
STANAG 4212	0.0075	**0.05%**	**0.04%**	**0.01%**	**0.01%**	**0.00%**	**0.00%**
	0.0015	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**
EUROCOM	0.0075	**0.03%**	**0.04%**	**0.02%**	**0.00%**	**0.00%**	**0.00%**
	0.0040	**0.04%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**

It was found that in the case of the SEAMCAT modelling that:

- interference from TRR into TAPS mobile stations is negligible
- interference from TRR into TAPS BS requires a frequency separation (distance between channel edges of the two adjacent band systems for them to co-exist) of 350 kHz as well as separation distances (gap between coverage of two base stations) of 80 kms (STANAG 4212) or 70 kms (Eurocom) depending on the TRR equipment.
- interference from TAPS BS into TRR (rural) requires a guard band of 750 kHz (Eurocom) or 1500 kHz (STANAG 4212) and no geographical separation.

F.3.2 Outcome of MCL modelling

The study used MCL (Minimum Coupling Loss) to investigate the impact of TAPS-BS into TRR (915 – 921 MHz) and TRR into TAPS-BS (870 – 876 MHz). The parameters used for the two systems are shown below:

TAPS-BS Parameters	
Tx Power	35 dBm
Antenna Gain	15 dB *
ERP	50 dBm
Bandwidth	200 kHz
Rx Sensitivity	-104 dBm
Protection Ratio	9 dB
Protected Sensitivity	-113 dBm

TRR Parameters	
Tx Power	37 dBm
Antenna Gain	16 dB *
ERP	53 dBm
Tx Bandwidth STANAG 4212	750 kHz
Tx Bandwidth EUROCOM	496 kHz
Rx Bandwidth	1500 kHz
Rx Sensitivity	-93 dBm
Protection Ratio	15 dB
Protected Sensitivity	-108 dBm

F.3.2.1 TAPS–BS into TRR (915 – 921 MHz)

Assumption: Blocking effects are more significant than unwanted emissions.

Required Path Loss	=	TAPS-BS ERP	-	TRR Protected Sensitivity	+	TRR Antenna Gain	+	TRR Blocking Protection
	=	50	-	-108	+	16	+	Varies with frequency separation

The output was the following figures

Figure F-6 MCL for TAPS-BS into STANAG 4212 TRR dependent on frequency separation (Source ECC Report 58)

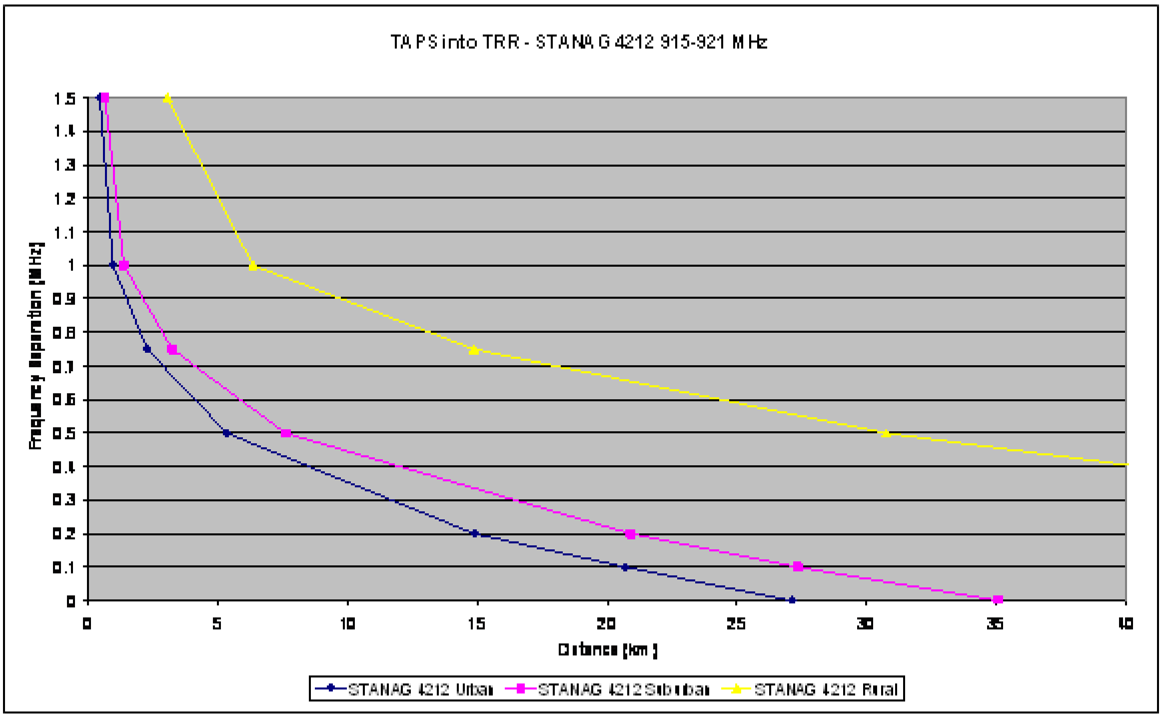
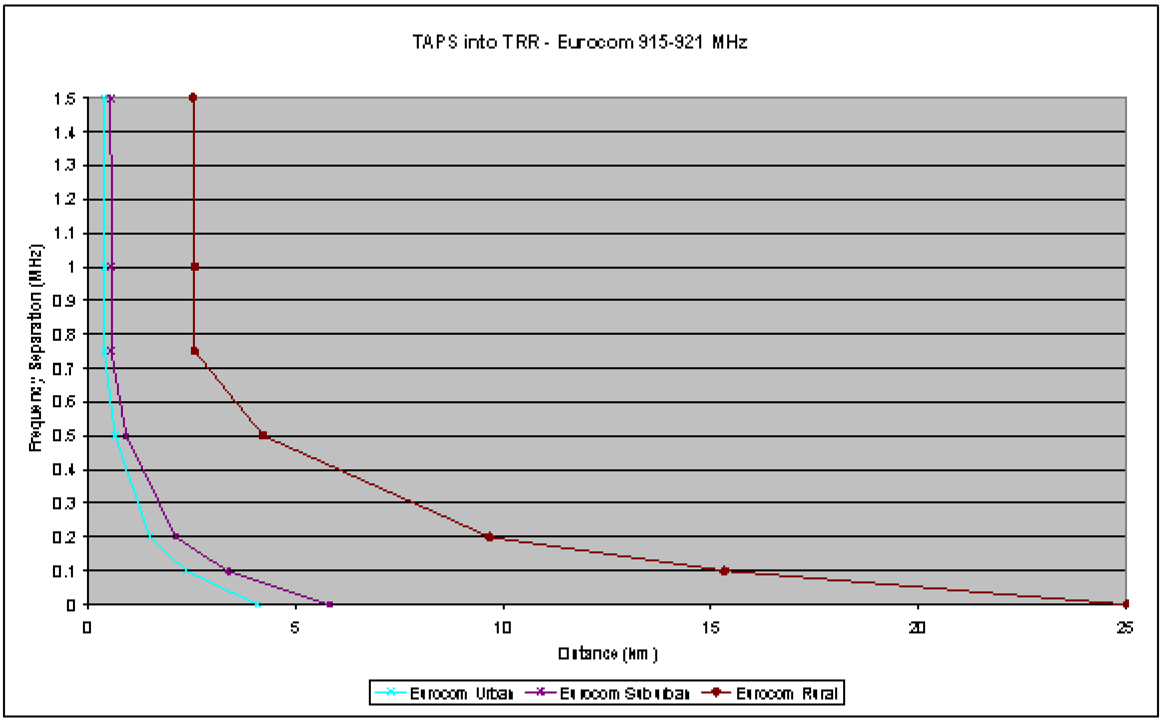


Figure F-7 MCL for TAPS-BS into Eurocom TRR dependent on frequency separation (Source ECC Report 58)



F.3.2.2 TRR into TAPS-BS (870 – 876 MHz)

Assumption: Blocking effects are more significant than unwanted emissions.

Required Path Loss	=	TRR ERP	-	TAPS-BS Protected Sensitivity	+	TAPS-BS Antenna Gain	+	TAPS-BS Blocking Protection
	=	53	-	-113	+	15	+	Varies with frequency separation and TRR emissions bandwidth

Figure F-8 MCL for STANAG TRR into TAPS-BS dependent on frequency separation (Source ECC Report 58)

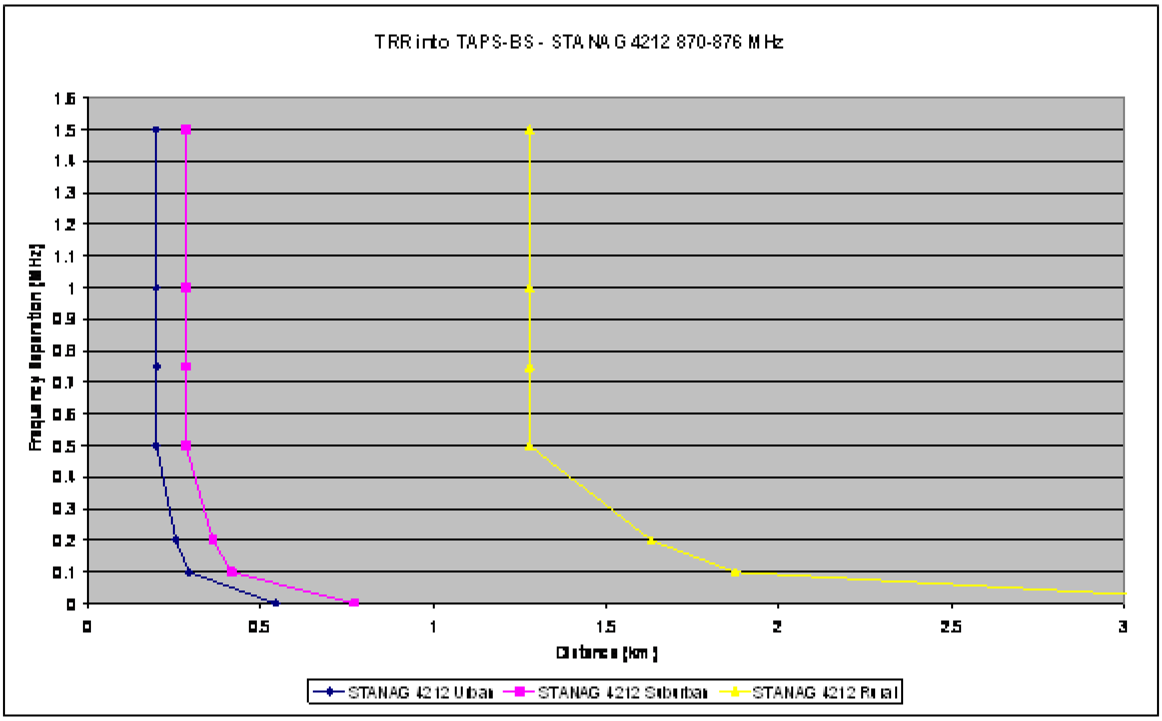
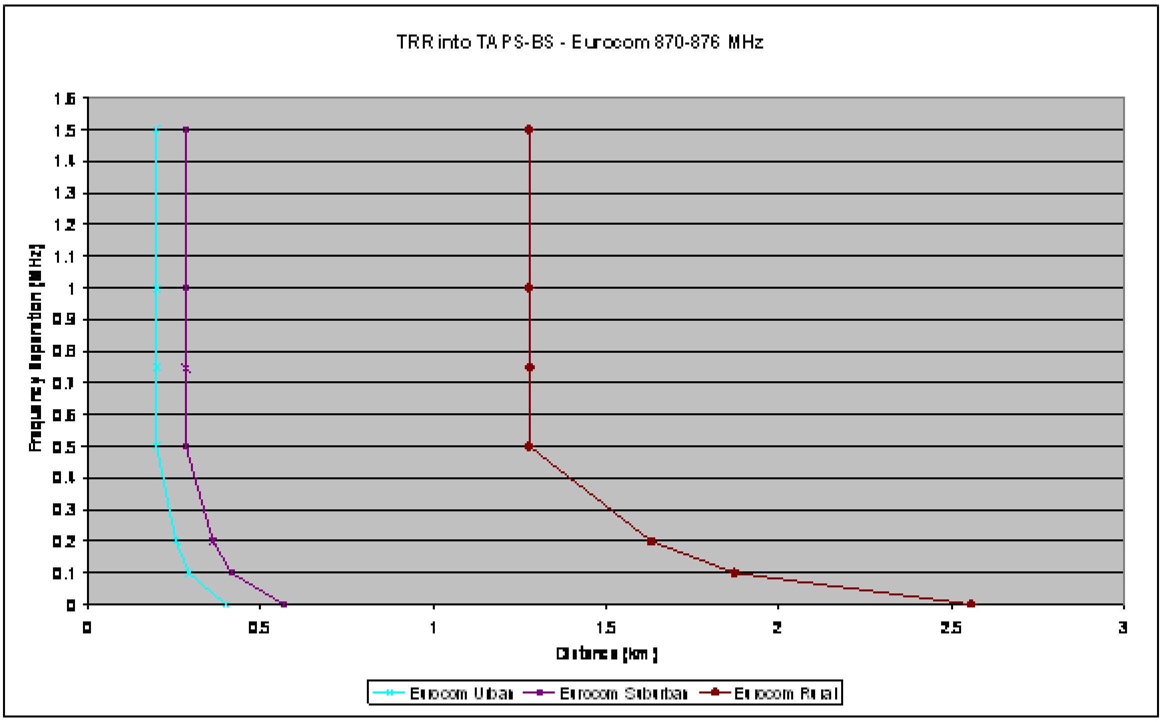


Figure F-9 MCL for Eurocom into TAPS-BS dependant on frequency separation (Source ECC Report 58)



The MCL modelling indicated that the potential for interference exists at very large distances but use of a frequency separation (defined as the minimum separation between the channel edges of the two adjacent band systems) such as 0.5 MHz will significantly reduce the required separation (gap) distances.

F.3.3 Overall Conclusions

It was concluded in ECC Report 58 that a combination of both frequency and physical separation would allow the two systems to be deployed. Also mitigation techniques could be deployed to facilitate the deployment of the systems, but potentially would require co-ordination:

- Use of directional antennas for TAPS base stations pointing away from known military exercise areas
- Optimise the alignment of the TRR antennas to minimise interference
- Careful selection of the frequency used by the TRR
- Use power setting of TRR to increase wanted signal level in case of interference – not ideal as will increase interference from TRR to TAPS
- During deployment of TRR reduce power of specific TAPs BS

F.4 Adjacent channel sharing between Electronic Communications Network (ECN) and Tactical Radio Relays (TRR)

The compatibility between ECN (with LTE operating in a 10 MHz band being a typical example) and TRR is very similar to the TAPS / TRR study above and could be used as an indication that there should be the potential for adjacent channel sharing provided there is a frequency and geographic separation between the two systems to optimise their co-existence. This of course assumes that the military equipment is similar to either the Eurocom or STANAG 4212 equipments.

The main differences are:

- Sharing between ECN and TRR needs to be considered in the rural environment as this is where utilising technologies such as LTE in the 800 MHz band can provide significant cost advantages in the provision of broadband services
- TAPS has a bandwidth of 200 kHz and ECN (LTE) a bandwidth of 10 MHz.
- TAPS BS transmit power is 35 dBm in a bandwidth of 200 kHz and for ECN (LTE) could be 64 dBm or even 70 dBm to provide coverage in rural areas. However it should be noted that the power is spread across different bandwidths and it is the power received by the TRR receiver that is important and it has a receiver bandwidth of 1500 kHz..
- Slightly different frequency bands

In practice the ability to utilise the duplex gap for TRR may also depend on the use of mitigation techniques including:

- Optimisation of the alignment of the TRR antennas to minimise interference into ECN BS
- Careful selection of the frequency used by the TRR (already used in practice to allow GSM sharing with the military)
- Increasing the power over the TRR link in one direction to overcome any interference
- Use of beam forming antennas for LTE that limit transmission in specific directions

Utilising guard bands, at each end of the duplex gap, could reduce the potential for interference. It may also be possible to agree deployment approaches with the military that allow most of the duplex gap to be utilised without the need for any, or only very small, guard bands. Probably as far as TRR is concerned the use of frequencies close to the FDD downlink will be the most prone to interference. However once the out of band emissions of the ECN base station start decreasing more rapidly (after 3 MHz from the lower edge of the duplex gap) then the potential for interference should decrease.

G ADJACENT CHANNEL INTERFERENCE RISKS BETWEEN TACTICAL RADIO RELAY (TRR) AND ELECTRONIC COMMUNICATIONS NETWORKS (ECN) AND DVB-T

G.1 Introduction

As part of this study we were specifically asked to comment on the adjacent channel risks between military use and electronic communications networks (ECNs) and DVB-T if the military were to utilise channels immediately below 61 - 69. In responding to this question we have assumed that the most likely military use is tactical radio relays[69] and the concern is not interference into tactical radio relay links but interference from these links into services that may be operated in adjacent channels, namely ECN and DVB-T as shown in the figure below:

Figure G-1 Military tactical radio relay links operating in spectrum adjacent to DVB-T and ECN

The actual deployment of the tactical radio relay will have an impact on the potential for interference into the adjacent services. For example if the tactical radio relay is only deployed in specific designated military areas then the potential for DVB-T receivers and also ECN user terminals to be located close to a tactical radio relay transmitter is significantly decreased. Also the tactical radio relay may only be used for a limited period of time as they are not normally used as a permanent link but deployed on an ad-hoc basis. The aim, when deploying a tactical radio relay link, should be to minimise the unwanted emissions from the tactical radio relay and ensure that the wanted signals to DVB-T receivers and ECN user equipment located geographically nearby are maximised.

G.2 Tactical radio relays (military) and ECN (digital dividend)

In theory there is the potential for interference into the ECN base station (BS) as well as into the UE (user equipment). However assuming ECN is FDD[70] and operating in the band 790 - 862 MHz and tactical radio relay operating in the channels just below then the interference scenario will be tactical radio relay interfering into the user equipment (UE)[71].

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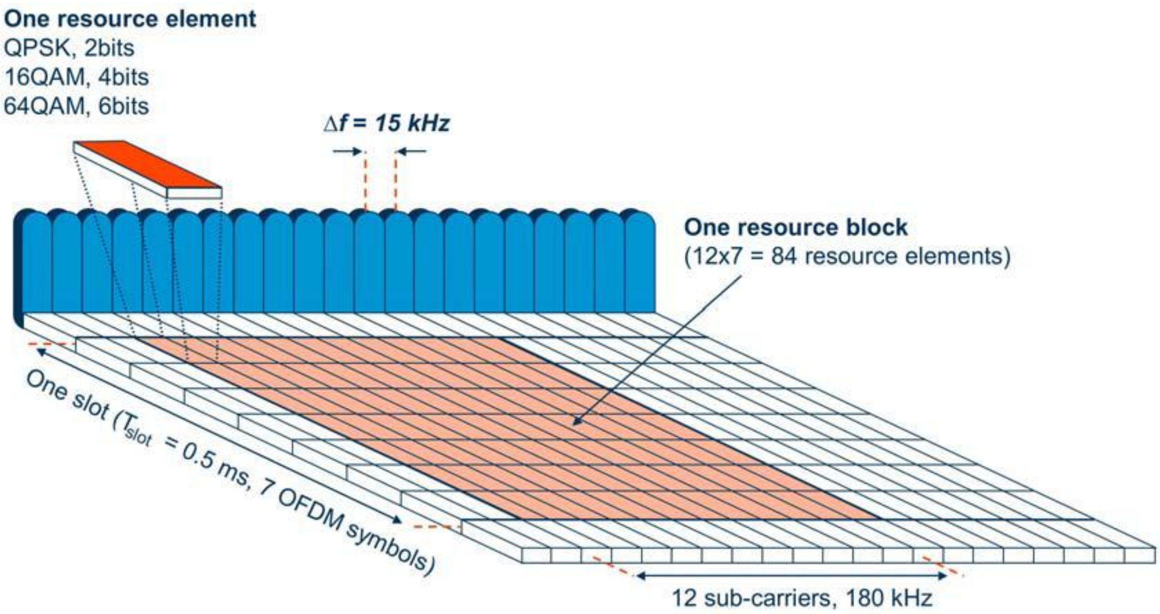
[69] This assumption is based on our understanding that tactical radio relay equipment considered in the sharing studies for TETRA TAPs can operate in lower frequency bands.

[70] There is also the option to utilise TDD and in this case it is proposed that there should be a guard band between the lowest channel and the adjacent service – see Annex A.

[71] This scenario is also covered in Annex F above

However if you consider, for example LTE, then in the downlink it uses OFDM which uses a large number of narrow sub-carriers for multi-carrier transmission. The basic LTE downlink physical resource is a time-frequency grid, as illustrated in the figure below. In the frequency domain, the spacing between the subcarriers, Δf, is 15kHz. The OFDM symbols are grouped into resource blocks. The resource blocks have a total size of 180kHz in the frequency domain and 0.5ms in the time domain. Each 1ms Transmission Time Interval (TTI) consists of two slots (Tslot). Each user is allocated a number of so-called resource blocks in the time–frequency grid. The more resource blocks a user gets, and the higher the modulation used in the resource elements, the higher the bit-rate. Which resource blocks and how many the user gets at a given point in time depend on advanced scheduling mechanisms in the frequency and time dimensions. Therefore there is the possibility that not all the resource blocks will be impacted by the interference and there is the potential to provide a service.

Figure G-2 LTE Downlink Physical Resource (Source Ericsson)



Also, in the worst case, if there is an interference problem it is likely that it can be resolved by moving to an alternative location. This is already something that cellular users have to do where there is limited coverage.

G.3 Tactical radio relays (military) and DTT

The issue here is interference from the tactical radio relay transmitter into the DVB-T tuners (receivers). Work has been undertaken in TG4 to measure the performance of DVB-T receivers in the presence of interference from the mobile service in terms of carrier-to-interference protection ratios and overloading thresholds in the presence of interference from the mobile service, especially from UMTS. The average receiver sensitivity measured was -81 dBm, assuming COFDM - 64 - QAM and a coding rate of 2/3 and a guard interval of 1/32. On the basis of UMTS interference into a DVB-T receiver, and an offset of 6.5 MHz, then the required protection ratio is - 31 dB and the maximum received interfering signal to avoid overload of the front end of the receiver is - 9 dBm.

It is noted in the report that the results from LTE may differ from UMTS and also that different DVB-T receiver types show different behaviour in response to interference. It is also interesting to note that at equal frequency offsets the impact of UMTS user equipment interference into a DVB-T receiver is considerably higher than the one from the base station and this effect has been linked to the use of transmitter power control. The use of transmitter power control increased the required protection ratio by 12 - 26 dB and decreased the overloading threshold detected by 7 - 11 dB depending on the frequency offset. It should also be noted that work in the UK found relatively poor performance of USB stick tuners used for computer viewing, as the channel offset between the UMTS interferer and the DVB-T stick tuner was increased. As far as we are aware no measurements have been undertaken to assess the impact of a tactical radio relay interfering signal into different DVB-T receivers.

The interference from a tactical radio relay link into a DVB-T fixed roof top installations could result in a far from ideal situation[72]. In ERC Report 106, Annex 4, there are some protection ratios for DVB-T subjected to transmissions of tactical radio relay - for example at a frequency separation of 4.5 MHz the protection ratio is -27 dB and this increases to -45 dB at 12 MHz. This is based on a DVB-T receiver sensitivity of - 78 dBm for 64-QAM and a coding rate of 2/3. Using the protection ratios from ERC Report 106, Annex 4 and assuming a Cmin of -78 dBm then the following interference levels (I max) will not impact on the reception of DVB-T:

I max = - 77 dBm at 3.75 MHz offset

I max = - 51 dBm at 4.5 MHz offset

Imax = - 33 dBm at 12 MHz offset

The required path loss of the tactical radio relay link can be calculated to ensure that it does not exceed the above I max values.

It has been assumed that the tactical radio relay link has a transmitter power of 50 dBm, an antenna gain of 16 dBi (both parameters from the Stanag 4212 standard) and the DVB-T receiver has an antenna gain of 13 dBi.

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[72] This is one reason why the UK decided to stop assigning new fixed links in the 11 GHz frequency band, even though satellite TV was a secondary service, because of the political ramifications of viewers losing their TV service.

From this the necessary separation distance between the tactical radio relay transmitter and the DVB-T receiver can be calculated using the Hata propagation model and assuming a frequency of 620 MHz, tactical radio relay transmitter antenna height of 30 m and DVB-T receiver antenna height of 10 m. The minimum separation distance results shown below assume that the DVB-T receiver is directly in the line of fire:

31 kms at 3.75 MHz offset

6.2 kms at 4.5 MHz offset

1.9 kms at 12 MHz offset

However it should be noted that these separation distance values are only indicative and based on historic information and assumptions that the tactical radio relay equipment is similar to the Stanag 4212 parameters. We would suggest that it might be useful for the military and other interested parties to undertake more detailed analysis based on likely deployments or even actual field measurements.

G.4 Minimisation of interference risks

To minimise the interference between tactical radio relay links into DVB-T and also ECN user equipment then many of the potential mitigation techniques listed in Annex 4 (Guidance to Administrations on the relevant mitigation techniques and means to solve or minimise the interference cases between ECN and terrestrial broadcasting) to the draft CEPT Report 30[73] could be helpful. However probably the first option to consider is the actual frequency planning of the tactical radio links and the potential to utilise channels as far away as possible from the band edge between the tactical radio relay and the DVB-T or the ECN BS transmitter channel as this will reduce the required protection ratio between the services. Other possibilities are:

- take advantage of any natural topographical features that would reduce the transmission of the tactical radio relay signal in directions other than the required line of fire.
- optimisation of the alignment of the TRR antennas to minimise interference into DVB-T and ECN:
- avoid operating on the edge of the TV reception where the TV received signal levels will be lower and therefore more prone to interference – the same applies to the coverage from an ECN base station
- limit the transmitter power of the tactical radio relay link to the minimum required to overcome any noise and / or interference over the link
- operate cross polar

[73] See the input document ECC(09)075 to the ECC meeting scheduled in June in the Isle of Man available on the ERO web site: www.ero.dk

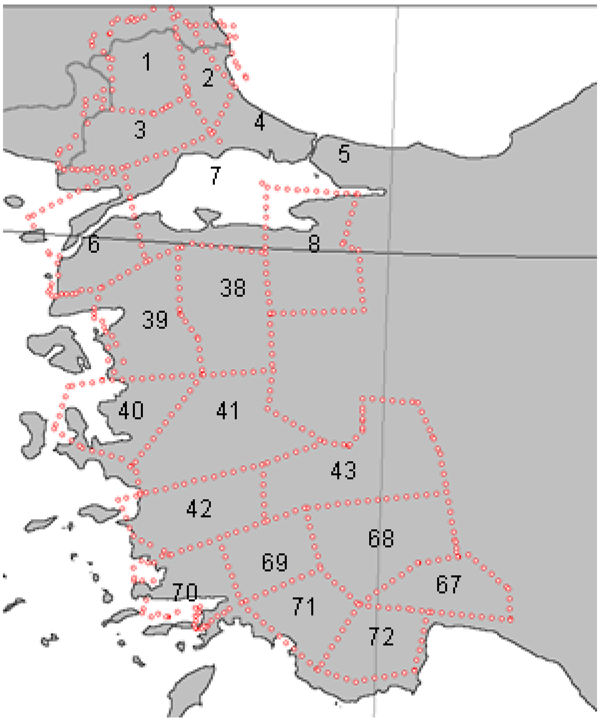
- addition of rejection filters into DVB-T receivers
- improved filtering of the tactical radio relay transmitted signals.

H POTENTIAL FOR INTERFERENCE BETWEEN MILITARY USE AND DVB-T

H.1 Cross-Border Interference from tactical radio relay into GE-06 Plan allotments

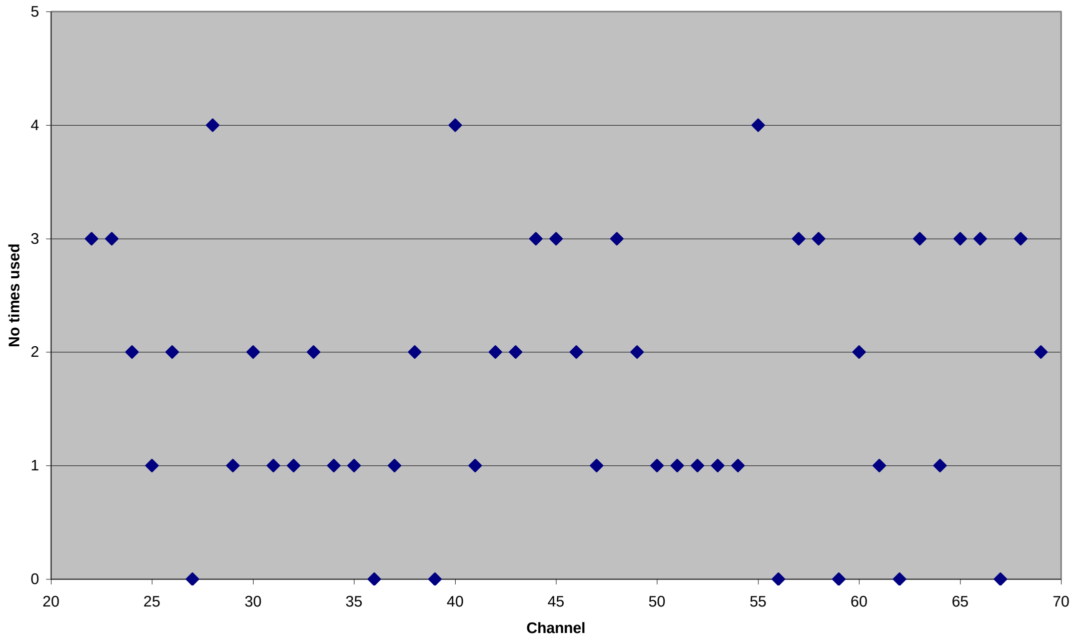
The figure below shows the different regions in Turkey that are located next to or close to the border with Greece and could experience interference if there is continued use of Channels 61 – 69 by the military. It should be noted that whatever part of the UHF band is used by the military there could be the potential for interference into services (broadcasting or mobile) in Turkey and as mentioned previously in the report the use of the current military spectrum was not notified or taken into account during the GE-06 planning.

Figure H-1 Turkey broadcasting areas according to GE-06 Plan



Based on the frequencies allocated in the GE-06 plan in regions 1, 3, 6, 7, 39, 40, 41, 42, 69, 70, 71 and 72 it can be seen from the figure below that there is a spread in the channels planned to be used with no obvious gap where it might be possible to deploy military services. It should also be noted that if Turkey plan to release channels 61 – 69 for non broadcasting services there may need to be increased use of the lower channels.

Figure H-2 Planned channel usage in Turkey located on or near the Greek border



The options that appear to cause minimal impact are channels 34 – 37 or channels 50 – 54. The two figures below show the regions where the channels are planned to be used in Turkey.

Figure H-3 Planned use of channels 34 – 37 in Turkey

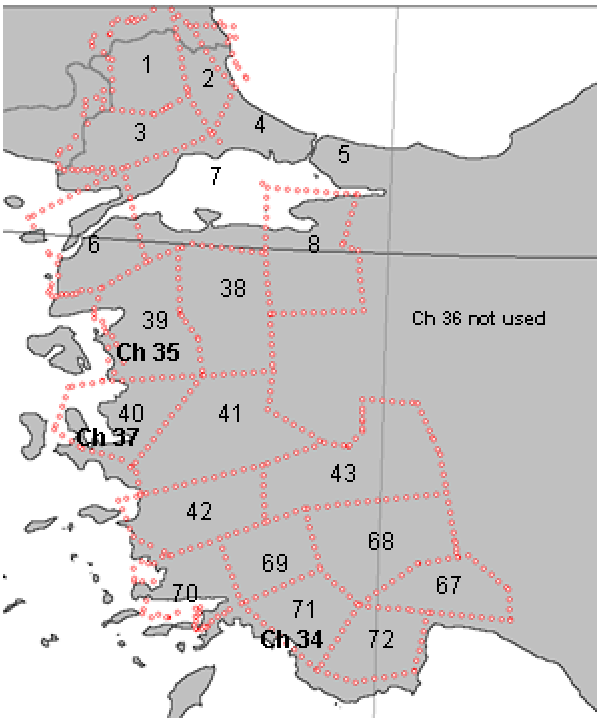
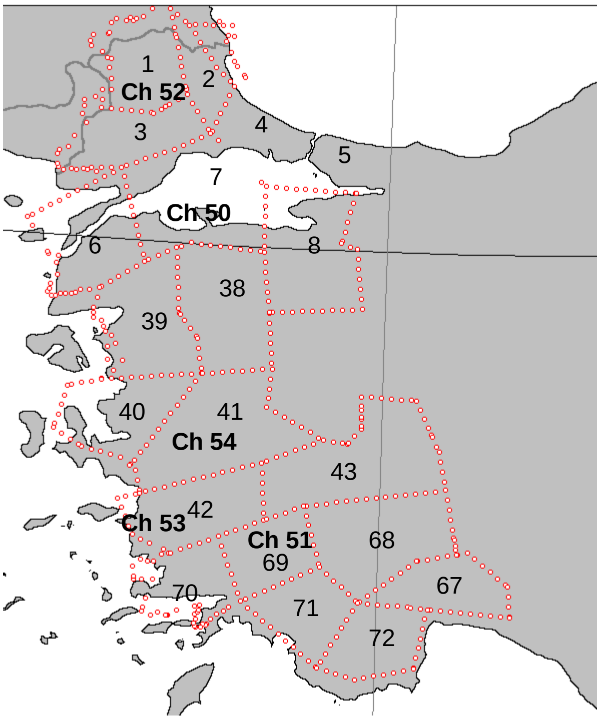


Figure H-4 Planned use of channels 50 – 54 in Turkey

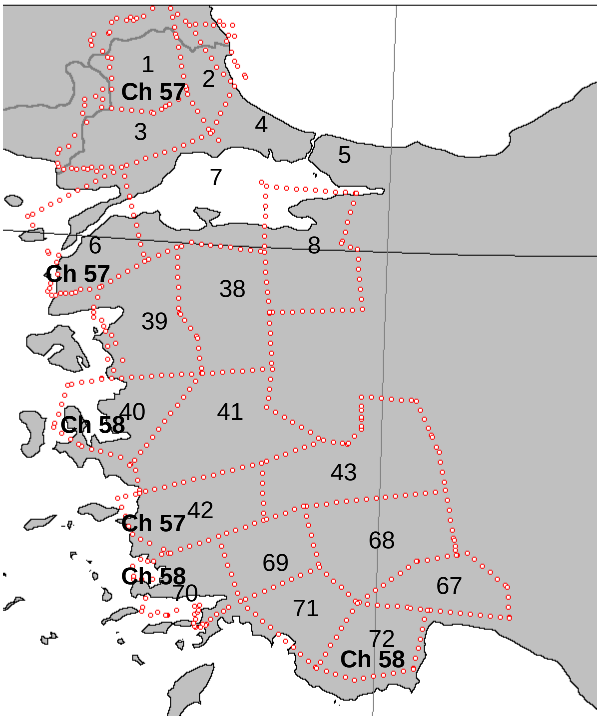


However based on the assumption that the military usage is for tactical radio relay links and that, according to the Stanag 4212 equipment parameters, it would not be feasible to adopt the Channel 34 – 37 option as it is outside the equipment tuning range of 610 – 960 MHz. Therefore, Channels 50 – 54 appear to be the best solution in terms of minimising tactical radio relay interference with broadcasting allotments in Turkey. In the regions identified the impact would be:

- Region 1 would have 8 channels rather than 9,
- Region 7 would have 5 channels rather than 6, however due to the geographic location the potential for interference is likely to be considerably lower
- Region 41 would have 7 channels rather than 8
- Region 42 would have 5 channels rather than 6, and
- Region 69 would have 6 channels rather than 7, however due to the geographic location the potential for interference is likely to be considerably lower.

If channels 57 – 58 were used for the military then the impact is shown in the figure below:

Figure 5-H Planned use of channels 57 – 58 in Turkey



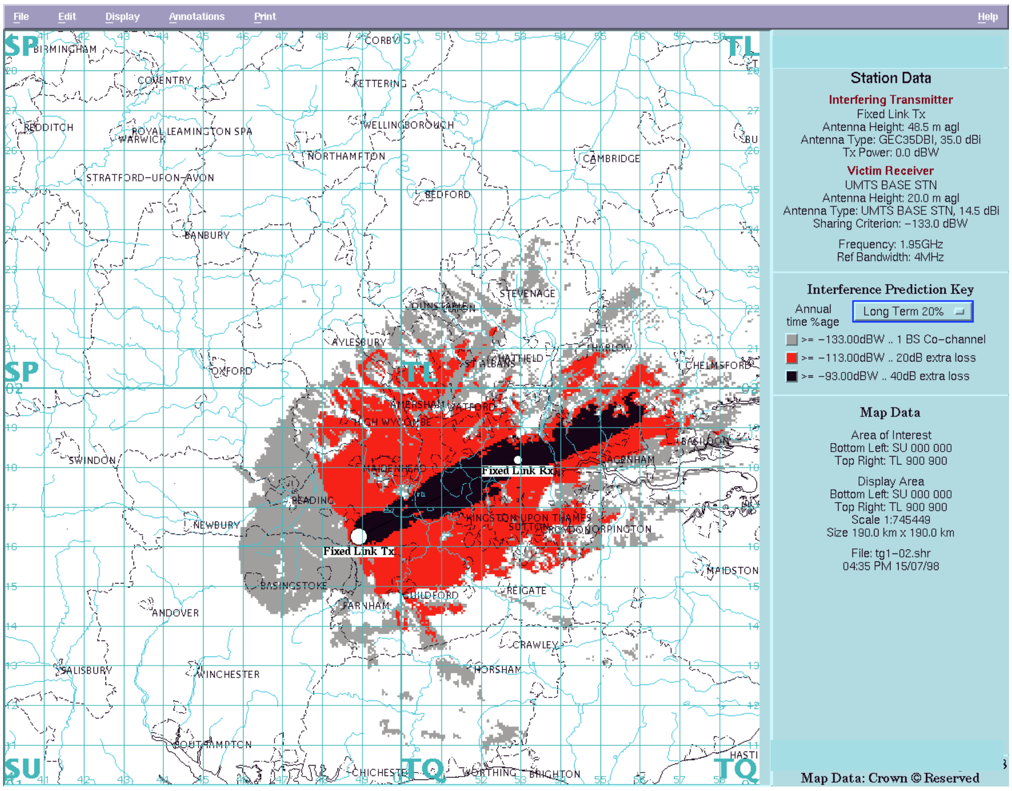
It can be seen that there is no region which will lose more than one channel. However more regions are impacted as both channels 57 and 58 are used more frequently in geographic areas adjacent to Greece.

H.2 Sharing criteria for co-channel operation

As far as we are aware there have been no studies undertaken to assess the feasibility of tactical radio relay links sharing with DVB-T systems. There have been studies undertaken within CEPT that considered the sharing between UMTS and fixed services in the 2 GHz band[74] and not surprisingly it was concluded that the sharing situation depended on the exact operational parameters of the UMTS and fixed service systems as well as factors such as terrain features. An example sharing study was undertaken and it can be seen from the figure below that the critical consideration is the geographic separation between the fixed service transmitter and the base station receivers in the main beam of the fixed service antenna as well as the terrain.

[74] ERC Report 64: "Frequency sharing between UMTS and Existing Fixed Services"

Figure H-6 Example sharing study (FS Tx into BS Rx) – long term interference (Source ERC Report 64)



It can be seen that 40 dB extra loss is required in the black area shown on the map to ensure that the maximum permissible interference power of -133 dBW, into a UMTS BS receiver is not exceeded for 20% of the time. This equates to a distance of around 90 kms in the main lobe of the fixed service transmitter.

The same sharing situation will apply to tactical radio relay links. The ability to geographically share the same frequencies will depend on the exact operational parameters of the tactical radio relay link and the digital TV receivers as well as factors such as terrain features. In the ongoing studies in CEPT, measurements of the performance of DVB-T receivers in the presence of interference from the mobile service have been analysed and there is a recommendation to undertake further measurements to assess the impact of LTE on the broadcasting service, as mentioned earlier. Similar studies may be required for tactical radio relay interference especially as different DVB-T receiver types show different behaviour in response to interfering signals, but this is not within the scope of the CEPT studies. It was, however concluded, that a protection ratio of around 17 dB may be necessary based on the protection ratio measurements of DVB-T interference into USB DVB-T receivers (Annex A of Draft CEPT Report on Deliverable D, 27 May 2009).

H.3 Implications for adjacent TV channels

Depending on the bandwidth and emission mask of the tactical radio relay (TRR) systems, there could be interference to TV reception on the adjacent channel – e.g. if channels 57 – 59 inclusive were to be used by TRR there could be interference to channels 56 or 60. This interference would be most likely to arise if TRR transmitters were located towards the edge of the coverage area of the local TV transmitter.

Providing that TRR links do not operate in the same area at both the upper and lower end of the allocated band (i.e. in the case of channels 57-59, in the lower part of channel 57 and the upper part of channel 59), no more than one adjacent channel would be affected (i.e. channel 56 or 60, but not both). Since there are no locations where both of these channels are used for DTT, there would therefore be no practical impact on the deployment of DTT if this is the case.

If it is necessary to deploy TRR links at both ends of the allocated band in the same location there are a number of ways in which the effect of this interference might be minimised. Firstly, the TRR systems are relatively narrow band (approximately 1 MHz) so it should be possible to configure the equipment so that a guard band of several MHz exists even where the adjacent TV channel is in use. This would eliminate the risk of interference in most cases. It may also be possible to set the polarisation of the TRR link so that this is orthogonal to the polarisation of the local TV transmitter, which would provide a further 10 – 15 dB of protection.

Further options include:

- Inserting additional filtering to the TRR transmitter output to reduce the out of band emissions.
- For permanent TRR transmit sites, deploy an on-frequency repeater to boost the signal level of the affected TV station.
- Re-configuration of the overlapping SFNs deployed in most of the coverage areas so that the affected broadcast channels are not deployed in the vicinity of the TRR transmitters.

as well as those mentioned in the Annexes above.

I GLOSSARY

BCH	Type of error correcting code used in DVB-T
CMD	Common Ministerial Decision
DTT	Digital Terrestrial Television
EBU	European Broadcasting Union
FDD	Frequency Division Duplex
IMT	International Mobile Telecommunications (3G mobile standard)
LDPC	Low Density Parity Check
LTE	Long Term Evolution of the IMT standard
RRC	Regional Radio Conference
TDD	Time Division Duplex
WRC	World Radio Conference