



Study on the possible combination of the 2.1GHz and 700MHz awards

Report for Ministry of Economic Affairs

22 February 2013

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Aetha Consulting Limited
Bidwell House
Trumpington Road
Cambridge
CB2 9LD
UK

Phone: +44 (0)1223 755 575
Fax: +44 (0)20 7183 3716
Email: enquiries@aethaconsulting.com
www.aethaconsulting.com

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1 Executive summary

This report has been prepared by Aetha Consulting Limited (Aetha) for the Ministry of Economic Affairs (“the Ministry”) as a summary of our research on the future use of the 2GHz and 700MHz bands and our recommendations on the timing of award of the frequencies in both bands.

1.1 Background

The “2GHz band” actually comprises three separate bands:

- the 2.1GHz paired band (1920-1980MHz paired with 2110-2170MHz) – this band is currently used for the provision of 3G services using UMTS technology – and is likely to be used for the next generation mobile technology, LTE, in the future
- the 1900MHz unpaired band (1900-1920MHz) – this band is currently largely unused
- the 2.0GHz unpaired band (2010-2025MHz) – this band is currently largely unused.

Licences for all three bands are due to expire on 1 January 2017.

The 700MHz band spectrum (694-790MHz) is currently utilised for the provision of digital television services using DVB-T technology. The commercial licence for this service is held by Digitenne (which is owned by KPN) and the licence is due to expire on 1 February 2017. Discussions are currently taken place at the European Union (EU) level on the possibility of making this spectrum available for electronic communications services i.e. the usage parameters would be compatible with use of the band for mobile technologies such as the next generation mobile technology, LTE.

The primary objective of this project was to understand whether it is appropriate for the Ministry to award the 700MHz and 2GHz band spectrum jointly in a single process (auction). Additionally consideration was given to whether the various 2GHz bands should be awarded together. Finally the study aimed to answer the question of “what is the appropriate timing for the auction(s)?”

The first consideration in respect of deciding whether it is appropriate to undertake a combined award of the 2GHz and 700MHz spectrum is whether there are **sufficiently strong linkages between the bands in respect of the business cases of likely users of the spectrum** (existing mobile operators and possibly potential new entrants) and whether the potential acquirers’ ability to execute their business case in one band is strongly dependent on their spectrum holdings in the other band.

The second consideration in respect of assessing the feasibility of a joint award was in relation to whether the availability of the spectrum in all bands is likely to be at broadly the same time. Whilst all existing licences for the 2GHz and 700MHz licences are due to expire in early 2017, there must also be synchronisation in respect of:

- **the timescale in which the bands will be available for use for electronic communications services** - as discussed above, whilst the 2GHz band is currently allocated to electronic communication services, the 700MHz spectrum is currently allocated to broadcast television
- **the timescale over which the bandplan and usage conditions for each band will have been specified** (usually at the European level)

- **the timescale in which mobile equipment (particularly user devices) will become available** on a widespread basis for each band.

It is the combination of the relative strength of the linkages between the two bands and the degree of co-occurrence of the timing of ‘maturity’ of both bands that essentially determines whether awarding both bands in a single award process is likely to yield significant benefits for the Netherlands.

If there is a delay in respect the availability of one band, delaying the award process for the other bands (and potentially therefore the availability of spectrum to the market) could be very costly in economic terms and, in such cases, it may be better to proceed with an award for those bands where the underlying regulations and licence conditions are confirmed.

1.2 Summary of recommendations

Our overall recommendations in respect of each of the bands are as follows:

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| <p>2.1GHz paired band (1920-1980MHz paired with 2110-2170MHz)</p> | <p>We recommend that the Ministry proceeds with the development of regulations and design and implementation of the process for the award of this band, independently of other frequency bands.</p> <p>An auction prior to the expiry of the existing licences would benefit the most likely potential acquirers of the spectrum as follows:</p> <ul style="list-style-type: none"> • KPN, T-Mobile and Vodafone would have the certainty required in respect of the future availability of the spectrum to invest in new technologies in the band (in particular LTE). • Tele2 (and possibly ZUM) would be able to compete for access to 2.1GHz paired spectrum which could be used to provide additional LTE capacity in the medium to long-term. |
| <p>2GHz unpaired bands (1900-1920MHz and 2010-2025MHz)</p> | <p>We recommend that the Ministry awaits the outcome of work being undertaken by CEPT¹ identifying new technical usage parameters for these bands (the results of which will start to become available from late 2013/early 2014), before making any decisions on the future of these bands - including the regulations governing use of the bands, the award process and the appropriate timing of the award.</p> <p>In any case, it is looking likely that the future European harmonised technical parameters for these bands will not be set with mobile technologies such as UMTS or LTE in mind, and that the most economically valuable uses of these bands will be for other services. Consequently there is not likely to be an economic case for combining the award of these bands with the award of the 2.1GHz paired spectrum.</p> |

¹ European Conference of Postal and Telecommunications Administrations – see www.cept.org for further details.

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| <p>700MHz band (694-790MHz)</p> | <p>We recommend that the Ministry monitor EU discussions in relation to this band and depending on how these progress, a timeline and award process for the 700MHz band can be set accordingly.</p> <p>We do not believe there is a case for linking the award of the 700MHz band with the 2.1GHz band as:</p> <ul style="list-style-type: none"> • There is considerable uncertainty over whether the political decision will be made to allocate the 700MHz band for electronic communications services across Europe, the timing that the spectrum would be available across Europe if that decision were to be made, and in the short-term there is also uncertainty over the technical usage parameters for the spectrum (including the bandplan to be adopted). • We have not identified any strong business case linkages between the 700MHz spectrum (in the event it was made available for mobile services) and the 2.1GHz band in respect of the most likely acquirers of the spectrum in both bands (KPN, T-Mobile, Tele2, Vodafone and ZUM). <p>Furthermore, EU discussions in relation to the future of the 700MHz band could take considerable time to be resolved and there could be a significant loss of benefits from the use of the 2.1GHz paired band if its award was delayed whilst the key 700MHz band decisions are made.</p> |
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We provide additional background in respect of our recommendations for each of the above frequency bands in the sections below. Further details can also be found in the main body of this report.

1.3 2.1GHz paired band

In 1999, the European Parliament and the Council adopted the UMTS Decision² under which Member States were required to make the 2GHz bands available for UMTS services by 1 January 2002. Licences were awarded to between 3 and 6 organisations in each country typically comprising a mixture of 2G network operators and new market entrant(s). 3G (UMTS) networks were subsequently deployed in each country and the 2.1GHz paired band became (and remains) the main band for providing 3G services.

In the Netherlands, the three larger mobile operators (KPN, T-Mobile and Vodafone) each currently hold 2x20MHz of spectrum in the 2.1GHz paired band.

Since the UMTS Decision, the European Union has moved to adopt a technology neutral licensing policy for new bands as well as removing technology restrictions in previously assigned bands. As part of this process, in November 2012 the European Commission issued a Decision³ which requires Member States,

² See ‘Decision 128/1999/EC on the coordinated introduction of a third-generation mobile and wireless communications systems (UMTS) in the Community’, published in the Official Journal of the European Community on 22 March 1999.

³ See ‘Commission Implementing Decision 2012/688/EU of 5 November 2012 on the harmonisation of the frequency bands 1920-1980MHz and 2110-2170MHz for terrestrial systems capable of providing electronic communications services in the Union’, published in the Official Journal of the European Union on 7 November 2012.

by 30 June 2014, to modify the technical usage parameters specified in the licences for the 2.1GHz paired spectrum to make them more flexible – in practical terms this means that the band can be used for technologies other than UMTS, such as LTE.

Continuation of the Ministry's current preparations for the award of the 2.1GHz paired spectrum (independently of other bands) would appear to be compatible with the plans of the most likely acquirers of the spectrum:

- KPN, T-Mobile and Vodafone will, over time, wish to deploy LTE technology in this band; however the 800MHz, 1800MHz and 2.6GHz bands are likely to remain the main focus for LTE network deployments in the short-term. Following the 2.1GHz award process, each of these operators will have the certainty of knowing how much 2.1GHz spectrum they will have in the longer-term, providing sufficient confidence in respect of making investments in new LTE equipment for use in this band in the latter part of the decade/early 2020s.
- Tele 2 is in the process of deploying its own mobile network and may be interested in acquiring 2.1GHz spectrum to provide additional LTE network capacity in the medium to long-term. This may also apply to ZUM (joint venture of Ziggo and UPC) in the event that it decides to deploy a macro-cellular base station network in the Netherlands using the venture's existing 2.6GHz spectrum holdings.
- It is possible that the 2.1GHz band may be of interest in 2017 to an organisation contemplating entering the market as a mobile operator (i.e. a complete new market entrant) as a means of deploying LTE technology, particularly since it is likely that almost all of the European LTE devices launching at this time will support LTE in the 2.1GHz paired band. However we believe such interest is unlikely given that mobile penetration exceeds 100% of the population and there will already be four competing network operators (potentially five, depending on ZUM's plans) in the market.

1.4 2GHz unpaired bands

The 1900MHz and 2.0GHz unpaired bands were also part of the UMTS Decision and it was intended that these bands would be used for the provision of 3G mobile technologies.

The 1900MHz unpaired band was awarded in most European countries on a licensed basis, typically in combination with the 2.1GHz paired spectrum blocks. In the Netherlands, KPN, T-Mobile and Vodafone each have had a 5MHz assignment in this band (which is due to expire at the end of December 2016). Additionally, T-Mobile acquired a further 4.9MHz of spectrum in this band as part of the recent multi-band auction (the licence for this assignment is also due to expire at the end of December 2016).

Many countries planned to make the 2.0GHz unpaired band available on a licence-exempt basis, whilst other countries licensed this spectrum to specific organisations – as for the 1900MHz unpaired spectrum. In the Netherlands T-Mobile has a long-standing 5MHz assignment in this band (which is due to expire at the end of December 2016). Again, T-Mobile acquired a further 9.7MHz of spectrum in the band as part of the recent multi-band auction (the licence for this assignment is also due to expire at the end of December 2016).

Usage of these bands for mobile services in many European countries has been minimal/non-existent, partially due to a lack of standardised equipment for the bands. In view of the limited interest in, and usage

of, the unpaired 1900MHz and 2.0GHz bands for mobile services to-date, in October 2012, the European Union's Radio Spectrum Committee^{4, 5} issued a mandate⁶ to CEPT to develop technical conditions for the 1900MHz and 2.0GHz bands to take account of a wide range of potential uses of the band other than for mobile communications networks. Specifically the mandate has identified a shortlist of potential harmonised uses of the 2GHz bands to be given priority, namely:

- Public Protection and Disaster Relief (PPDR) – with preference to ad-hoc (non-permanent) PPDR networks
- Programme making and special events – preferably for use by wireless cameras
- Short range devices (SRD), preferably for improving energy saving and/or energy efficiency
- Additional spectrum for the Digital European Cordless Telephone (DECT) – including innovative applications such as machine to machine, preferably in the 1900MHz band
- Broadband Direct Air-to-Ground Communications (BDA2GC), preferably in a paired spectrum arrangement.

The European Commission requires the CEPT to provide a final report by November 2014; however initial results should be available from the end of 2013.

It therefore appears that the Ministry should await the initial results of the studies undertaken by CEPT on the compatibility of new potential uses of the 2GHz band before starting to make decisions about the award of the spectrum. It seems highly likely that the spectrum will no longer be harmonised with technical parameters that are primarily compatible with use of the band for mobile technology deployment and therefore there is no longer a case for awarding the 1900MHz unpaired and 2.0GHz unpaired bands in the same process as the award of the 2.1GHz paired spectrum band.

1.5 700MHz band

The 694-790MHz (700MHz) band is currently used for terrestrial television broadcasting across the European Union. During the World Radiocommunications Conference in 2012 (WRC-12), an agreement was reached (subject to final confirmation in WRC-15) to make a Primary allocation to wireless broadband alongside broadcast services in the 694-790MHz⁷ band from 2015 across the whole of ITU Region 1 (covering Europe, the Middle East and Africa).

⁴ The Radio Spectrum Committee (RSCOM) is a committee of Member States representatives. It approves EU spectrum harmonisation measures (proposed by the European Commission) under delegated power from the Council of the EU (gathering of governments of the 27 countries in the EU representing the individual Member States). These spectrum harmonisation measures then lead to a Commission Decision which has immediate validity.

⁵ See '*Radio Spectrum Policy Group: Commission activities related to radio spectrum policy*', Document RSPG12-437, European Commission, 25 October 2012.

⁶ See '*Draft Mandate to CEPT to undertake studies on the harmonised technical conditions for the 1900-1920 MHz and 2010-2025 MHz frequency bands in the EU*', Document RSCOM12-17 rev 3, European Commission, 10 September 2012.

⁷ Note that the lower edge of this band is to be confirmed as part of WRC-15.

The decision at WRC-12 has led to considerable interest being raised from the mobile community across Europe in respect of the feasibility of creating a 700MHz band for mobile services. Decisions on the future use of the 700MHz band need to be taken at a European level. This is primarily because of the nature of television broadcasting which utilises high power transmissions which travel significant distances across border regions. Thus a country cannot individually make a decision to change use of the 700MHz frequencies from television broadcasting to mobile services as broadcast signals from neighbouring countries could prevent the use for mobile services in significant regions of the country.

In order for the 700MHz band to become available for mobile broadband services several significant issues need to first be resolved:

- **EU Member States need to agree that the band will be allocated to electronic communications services** - this is a highly political issue and individual countries have very different positions in respect of the importance of the digital terrestrial platform to their economies and societal well-being. The creation of the 700MHz band would result in the loss of approximately 30% of the remaining UHF spectrum used for television broadcasting and would therefore require changes to the broadcasting network infrastructure (e.g. use of single frequency networks in place of multi frequency networks, the deployment of new broadcasting sites operating at lower power levels, replacement of existing consumer digital television receivers with ones that are compatible with DVB-T2 technology and the MPEG-4 compression specification, a possible requirement for some consumers to replace/alter the direction that their rooftop aerials are facing) or/and potentially a reduction in the number of television channels that can be supported on the platform, as a result of the reduction in the amount of spectrum available for broadcasting. At the present time, the process and timescale for making a European Union decision is unclear, although this may be clarified following the European Commission's publication of a Communication on an Action Plan for Wireless Communications⁸ in the next few months.
- **Agreement needs to be reached on the date from which the band will become available** – whilst some countries (such as Finland) would like the band to be available from the start of 2017, we regard 2020 as a more realistic timeline for a date from which the spectrum can be made available on a pan-European basis.
- **The technical conditions for the use of the band need to be agreed, including the bandplan** – in this regard the European Commission has drafted a Mandate to CEPT⁹ to develop these technical conditions. In doing so, the European Commission emphasised that this mandate was without prejudice to any future political decision at EU level on the future use of the 700MHz band in the EU.
- **Significant re-planning and reconfiguration of digital terrestrial television networks will need to occur** – in this respect, a Work Group of the Radio Spectrum Policy Group (RSPG)¹⁰ has prepared a

⁸ See 'Roadmap: Action Plan on Wireless Communications for a Connected Europe', European Commission DG Connect B4, February 2013.

⁹ See 'Draft Mandate to CEPT to develop harmonised technical conditions for the 694-790MHz ('700MHz') frequency band in the EU for the provision of wireless broadband', Document RSCOM12-37, European Commission, December 2012.

¹⁰ The Radio Spectrum Policy Group (RSPG) is an advisory group assisting the European Commission (and, on request, also the Parliament and Council) with the development of spectrum management policy. The RSPG comprises senior representatives from Member States (typically from the national regulator and/or ministry responsible for communications) and a representative from the EC.

draft report¹¹ which has highlighted the complexity that would be involved in re-planning the band and indicated that a period of around three years would be needed to reach the cross border agreements required and that the main part of this process cannot begin until WRC-15 has made a decision about the 700MHz band allocation and the EU has made decisions on the future use of the band. Time will also then be required to implement the network and frequency configurations changes – some of which could be significant.

It can therefore be seen that there is a huge amount of uncertainty over the creation of the 700MHz band – including in relation to the timescale during which the decision to allocate/not to allocate the spectrum to electronic communications services will be made. There could be many delays in the 700MHz decision-making process and a linkage of the 2.1GHz band award with the 700MHz band award could result in delays to the award of the 2.1GHz spectrum and the timescale for the introduction of LTE services in the band.

At the same time, we have not identified any upside benefits that would arise from linking the award of the two bands:

- The main benefit of the 700MHz band for mobile service provision is as a coverage layer for mobile technologies – providing additional capacity for LTE in less populated regions and in respect of deep indoor coverage. In this respect, the alternative bands to the 700MHz band are the 800MHz and 900MHz bands.
- The main benefit of the 2.1GHz band for mobile service provision is for continuing provision of 3G services and in the medium to long-term for providing additional LTE network capacity in urban areas (supplementing spectrum in the 1800MHz and 2.6GHz bands).
- There is no clear linkage between the 700MHz and 2.1GHz bands in respect of the business cases of the main potential acquirers of the spectrum (namely KPN, T-Mobile, Tele2, Vodafone and (possibly) ZUM). Each of these organisations is likely to independently place value on spectrum in the 700MHz and 2.1GHz bands – the business case for one band is unlikely to be materially affected by whether the operator is successful in acquiring spectrum in the other band.
- We note that a complete new market entrant could have a business case reliant on both 700MHz spectrum (to provide an LTE coverage layer) and 2.1GHz spectrum (to provide additional LTE network capacity)¹², but we believe that such a business case of a new entrant is highly unlikely to be viable given mobile market penetration and the number of existing operators in the market and consequently we do not expect such demand to materialise in an award process.

In view of the lack of upside benefits from combining the 700MHz and 2.1GHz awards, coupled with the risk that the uncertainties and delays in the 700MHz decision-making process could result in a significant loss of benefits as a result of delays in the use of the 2.1GHz band for new technologies (such as LTE) and delays in part of this band potentially being made available to new licensees (e.g. Tele2 and ZUM), we recommend against combining the 700MHz and 2.1GHz award processes at this time.

¹¹ See 'Draft RSPG Report on proposed spectrum coordination approach for broadcasting in the case of a reallocation of the 700MHz band', Document RSPG12-433, 25 October 2012.

¹² We also note that if the business case of a new entrant was dependent on having access to both 700MHz and 2.1GHz spectrum, this may necessitate the Ministry setting-aside spectrum in both bands for new entrants as part of the regulations for a combined auction.

2 Introduction

Aetha Consulting Limited (Aetha) has prepared this report for the Ministry of Economic Affairs (“the Ministry”) as a summary of our research on the future use of the 2GHz and 700MHz bands and our recommendations on the timing of award of the frequencies in both bands.

2.1 Background

In late 2012, the Ministry conducted an extensive multi-band spectrum auction (primarily comprising the entire spectrum in the 800MHz, 900MHz and 1800MHz paired bands and the entire spectrum in the 2.6GHz unpaired band)¹³. Following this award process, the Ministry has started work on the process for awarding licences in the 2GHz band which are due to expire on 1 January 2017. This spectrum comprises:

- the 2.1GHz paired band (1920-1980MHz paired with 2110-2170MHz) – which is currently used for the provision of 3G services using UMTS technology – and is likely to be used for the next generation mobile technology, LTE, in the future
- the 1900MHz unpaired band (1900-1920MHz) – 4.9MHz of spectrum in this band was included in the recent multi-band auction (the licence duration was limited to four years)
- the 2.0GHz unpaired band (2010-2025MHz) – 9.7MHz of spectrum in this band was included in the recent multi-band auction (the licence duration was limited to four years).

In addition to considering whether the above bands should be awarded in one combined process, the Ministry is seeking to understand whether it is likely to be beneficial to combine the 2GHz band award with the award of other frequency band(s). Specifically, the Ministry wishes to understand if there is a case for combining the 2GHz band award with that of the 700MHz band.

The 700MHz band spectrum (694-790MHz) is currently utilised for the provision of digital television services using DVB-T technology. The commercial licence for this service is held by Digitenne (which is owned by KPN) and the licence is due to expire on 1 February 2017. Discussions are currently taken place at the European Union (EU) level on the possibility of making this spectrum available for electronic communications services i.e. the usage parameters would be compatible with use of the band for mobile technologies such as the next generation mobile technology, LTE.

The primary objective of this project was to understand whether it is appropriate for the Ministry to award the 700MHz and 2GHz band spectrum jointly in a single process (auction). Additionally consideration was given to whether the various 2GHz bands should be awarded together. Finally the study aimed to answer the question of “what is the appropriate timing for the auction(s)?”

These questions are answered in this study by considering:

- the technology developments in the 2GHz band (considering both the 2.1GHz paired band and the two unpaired bands separately) and the business models for use of the spectrum

¹³ See “*Press Release: Multiband frequency auction completed*”, Agentschap Telecom, Ministrie van Economische Zaken, 14 December 2012 for further details.

- the likely future evolution of use of the 700MHz band, with particular respect to the timing over which the 700MHz band could become available for mobile use and the business models supporting such use of the spectrum.

2.2 Overview of study approach

The first consideration in respect of deciding whether it is appropriate to undertake a combined award of the 2GHz and 700MHz spectrum is **whether there are sufficiently strong linkages between the bands** in respect of the business cases of likely users of the spectrum (existing mobile operators and possibly potential new entrants) and whether the potential acquirers' ability to execute their business case in one band is strongly dependent on their spectrum holdings in the other band. Such linkages might arise as a result of:

- the **complementary** nature of the bands – for example a new entrant may require a portfolio of low frequency (to provide cost effective network coverage) and high frequency spectrum (to provide sufficient network capacity) in order to have a viable business case
- **substitutability** between the bands – for example, if the main benefit of additional spectrum is in respect of additional network capacity in highly populated areas, then the two bands may be substitutes and there may be advantages in awarding the bands at the same time to avoid any artificial scarcity issues.

In addition to the linkage between bands from the perspectives of potential users of the spectrum, there may also be significant efficiency benefits from holding a combined award in respect of the resources that need to be devoted by the regulator when preparing for and holding spectrum auctions.

Multiple bands can only be awarded in a joint process when the regulations governing the use of all bands and the timing of availability of spectrum in all bands are known – if there is a delay in respect of one band, delaying the award process for the other bands (and potentially therefore the availability of spectrum to the market) could be very costly in economic terms and, in such cases, it may be better to proceed with an award for those bands where the licence terms are confirmed.

Consequently, the second major consideration in respect of assessing the feasibility of a joint award of 700MHz and 2GHz spectrum is in relation to the 'maturity' of the spectrum bands. This includes consideration of issues such as:

- **The timescale in which the bands will be available for use** for electronic communications services (as discussed above, whilst the 2GHz band is currently allocated to electronic communication services, the 700MHz spectrum is currently allocated to broadcast television).
- **The timescale over which the bandplan and usage conditions for each band will have been specified** (usually at the European level)- this applies in relation to both the 2.1GHz paired spectrum (enabling it to be used by next-generation mobile technologies such as LTE) and also to the 700MHz band (enabling it to be used for mobile technologies).
- **The timescale in which mobile equipment (particularly user devices) will become available** on a widespread basis for each band (this particularly applies in relation to the availability of LTE equipment for the 700MHz and paired 2.1GHz bands).

It is the combination of the relative strength of the linkages between the two bands and the degree of coincidence of the timing of ‘maturity’ of both bands that essentially determines whether awarding both bands in a single award process is likely to yield significant benefits for the Netherlands.

2.3 Structure of this report

The remainder of this report is structured as follows:

- Section 3 provides background on the future spectrum requirements of the mobile operators’
- Section 4 discusses the 2GHz band (including both the paired 2.1GHz band and unpaired 1900MHz and 2.0GHz bands) particularly in relation to the likely timescale that mobile operators will wish to introduce LTE technology into the 2.1GHz paired band and the likely future use(s) of the unpaired bands
- Section 5 discusses the status of current European-level discussions on the 700MHz band and the timescale from which the spectrum could be used for electronic communications services and the expected timescale over which decisions are likely to be made in respect of the future use of this band
- Section 6 combines the assessments presented in Sections 4 and 5 and discusses the benefits from, and feasibility of, combining the awards of the 700MHz and 2GHz bands
- Section 7 details the main conclusions from the study.

3 Mobile operators' spectrum roadmap

In this section we discuss the spectrum strategies of mobile operators, specifically discussing the potential role of the 700MHz band and the 2.1GHz paired band within this. Section 3.1 discusses the mobile operators' requirement for a portfolio of spectrum holdings and Section 3.2 introduces Carrier Aggregation Technology and discusses how this may impact on mobile operators' spectrum strategies in the future.

3.1 Requirement for portfolio of spectrum

Mobile operators seek spectrum across a combination of frequency in order to:

- **provide network coverage on a cost-effective basis** – “low frequency” spectrum (typically frequencies below 1GHz) provide the best propagation characteristics meaning that signals travel further indoors and also travel greater distances generally. Consequently low frequencies are important for providing deep indoor coverage and also allowing less populated areas (often rural regions) to be covered using fewer numbers of base stations than would be required at higher frequencies – thereby resulting in lower network costs (both upfront capital expenditure to deploy new sites and on-going operating expenditure to keep the sites running and connected to the core network)
- **provide high levels of network capacity** – additional frequencies are needed to provide higher levels of capacity at each base station site. In the absence of such additional frequencies, additional base station sites would need to be deployed to provide similar levels of network capacity – sometimes such densification of the network is not possible due to a lack of availability of sites and/or planning approval constraints. There is more availability of spectrum at high frequencies (frequencies between 1GHz and 3GHz), so these tend to be used to provide additional network capacity significantly beyond that which could be provided using low frequencies
- **provide the highest data rates** – large individual channel widths (e.g. 20MHz for LTE) are required in order to provide the highest peak data rates and also maximise the efficiency of use of the spectrum. In practice, low frequency bands are very limited in capacity (e.g. a total of 2x30MHz of spectrum is available in the 800MHz band and a total of 2x35MHz of spectrum is available in the 900MHz band), and so the only way that multiple mobile operators can have access to the 2x20MHz of spectrum that is needed (per operator) for LTE is to make use of high frequencies. For example, the 2.6GHz band currently represents the main means for multiple operators to deploy LTE networks deploying the most efficient 2x20MHz channels
- **support multiple technologies concurrently** – consumers migrate from less advanced to more advanced technologies over time (e.g. from 2G handsets to 3G smartphones) but this period can be extensive and whilst the migration is taking place, spectrum is required to support multiple technologies concurrently. Whilst the migration to each new generation of technology results in a significant gain in spectral efficiency, during the period whilst the migration is taking place additional spectrum is required to support both the old (less spectrally efficient) technology and the more modern advanced (more spectrally efficient) technology. Spectrum needs to remain allocated to the older technology until the last remaining subscribers are migrated to the newer technology – meaning that although, in the longer-term, the introduction of a new technology provides a spectral efficiency gain (and means that less spectrum is required to provide the same services), in the short-term more spectrum is needed as both the old and new technologies need to be supported concurrently.

At the present time, consumers have a mixture of 2G (GSM), 3G (UMTS) and 4G (LTE) user devices and therefore network operators required sufficient spectrum to support all three technologies. Additionally, as indicated above, both low frequencies are needed for each individual technology in order to provide the ‘coverage layer’ for each technology and high frequencies are needed in order to provide additional capacity for each technology and support peak-data rates.

The rapid growth in data traffic on mobile networks is further increasing the need for additional spectrum to be found to support mobile networks and enable the deployment of the next generation of technology (LTE-Advanced) where channel widths of up to 100MHz will be required in order to support peak data rates of over 1Gbps. In its most recent forecast¹⁴, Cisco estimated that mobile data traffic in Western Europe will grow from 181,397 TB per month in 2012 to 1,384,072 TB per month by 2017 (a compound annual growth rate of 50%). Whilst there is considerable debate amongst industry analysts about the exact pace of growth in the future, there is consensus that there will be significant growth in the future. Mobile operators require a combination of tools in order to support such traffic growth – making use of new network technologies, making changes to the network architecture (e.g. increased deployment of small cells) and making use of new spectrum bands are all needed and only when utilised together will they enable the forecasts of growth in mobile data traffic levels to be realised.

The main agenda item for the next World Radiocommunications Conference (WRC-15) is the consideration of new spectrum bands to support the growth in mobile broadband services. As part of its Radio Spectrum Policy Programme¹⁵, the European Union has set the European Commission the target of identifying 1200MHz of spectrum (including the existing harmonised bands) to support growth in wireless broadband traffic. Several candidate bands are currently under consideration/study by the International Telecommunications Union as potential new bands for mobile broadband services, including the re-allocation of the 700MHz band in Europe (which is one of the bands under study in this report). Another means of enhancing network capacity involves the gradual re-farming (migration of) existing frequency bands from being used to support older (less spectrally efficient) mobile technologies to being used instead for newer (more spectrally efficient) technologies.

Figure 3-1 provides an illustration of a typical Western European mobile operator’s spectrum strategy showing the need for a portfolio of spectrum to support the concurrent deployment of multiple network technologies utilising a mixture of low frequency spectrum (for the technology’s ‘coverage layer’) and high frequency spectrum (to support higher capacities and the highest peak data rates).

It can be seen that the 900MHz and 1800MHz bands are the main bands for the deployment of 2G (GSM) technology and it is unlikely that GSM networks will be switched-off until around 2025, but part of these spectrum bands can over time be migrated to new technologies. 3G (UMTS) technology was initially deployed using the 2.1GHz paired spectrum (which is a key band under consideration in this study) with any ‘spare’ 900MHz spectrum being used (where available) to provide the low frequency coverage layer. 4G (LTE) technology is being deployed using the 800MHz band (coverage layer) and a mixture of the 1800MHz band (where sufficient spectrum can be freed-up from existing GSM services as subscribers migrate to UMTS) and the 2.6GHz band is being used to provide the capacity layer.

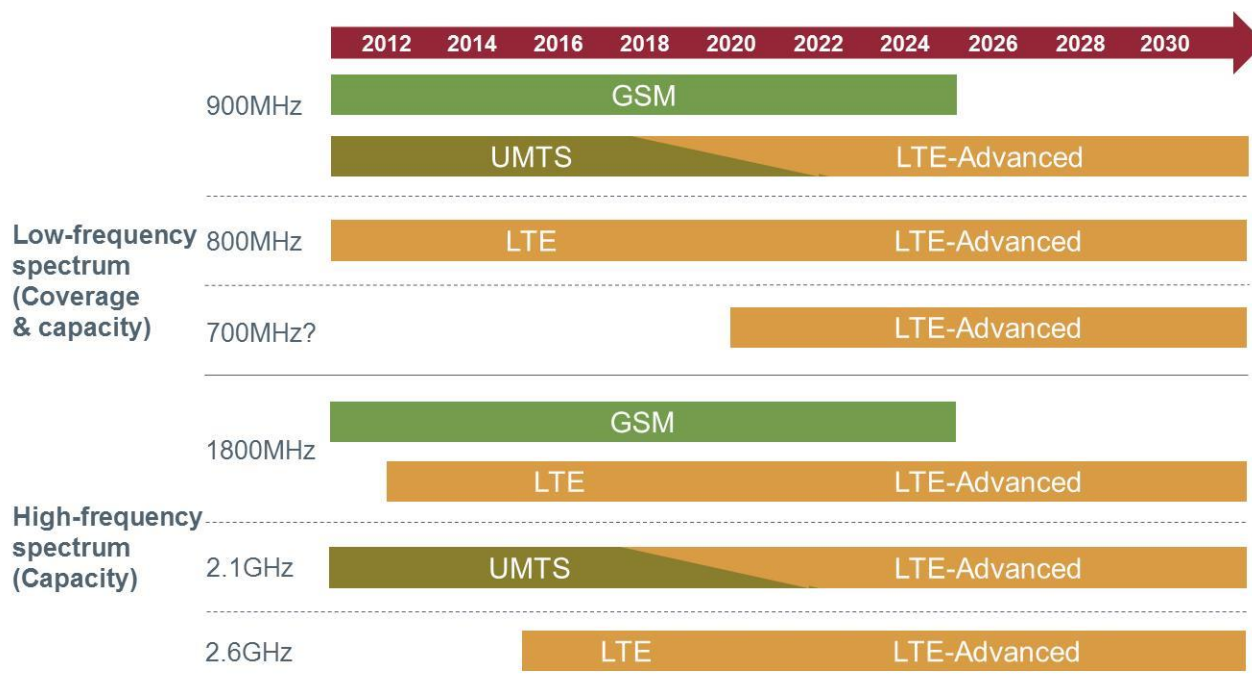
¹⁴ See ‘Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2012-2017’, Cisco, 6 February 2013.

¹⁵ See ‘Decision No 243/2012/EU of the European Parliament and of the Council of 14 March 2012 establishing a multi-annual radio spectrum policy programme’, published in the Official Journal of the European Union, 21 March 2012.

As we discuss in Section 4.1, it is likely that over time, spectrum in the 2.1GHz paired band can become available for LTE and LTE-Advanced technology as consumers update their devices from 3G to 4G technologies. The timing shown for this in the diagram below is purely illustrative – we discuss this issue further in Section 4.1.

Spectrum in the 700MHz band could be used to provide additional low frequency spectrum supporting the deployment of LTE and LTE-Advanced networks. Again the possibility of and timing that is shown in the diagram is purely for illustrative purposes – we discuss this further in Section 5.

Figure 3-1: Illustration of a mobile operator's spectrum strategy



3.2 Carrier Aggregation Technology

Carrier Aggregation Technology (CAT) allows operators to virtually aggregate spectrum holdings in different bands¹⁶ in order to deploy a larger (and more spectrally efficient) carrier. CAT is a core component of LTE Advanced (3GPP Release 10) which anticipates that up to five 2x20MHz channels can be combined to offer data rates of up to 3Gbps.

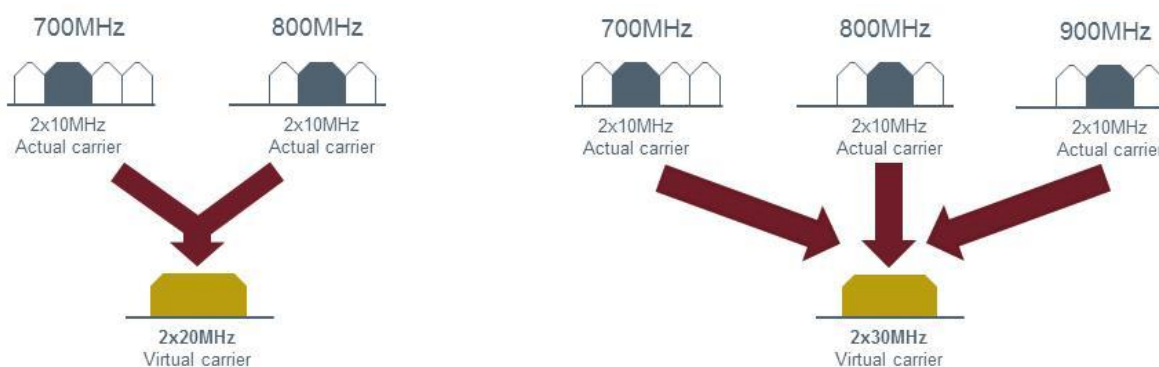
In the USA, AT&T is pushing for CAT to be developed in advance of LTE-Advanced being deployed to enable it to combine spectrum from different frequency bands to increase the speeds offered over its current LTE network. AT&T is aiming to deploy CAT on its network from 2014.

CAT could be used in Europe to allow operators to deploy LTE and LTE-Advanced services at higher peak rates without having to own contiguous spectrum. Whilst the primary use of CAT is likely to be in high frequency bands in which 20MHz carriers are combined to produce virtual carriers up to 100MHz bandwidth in order to provide the highest data rates supported by LTE-Advanced technology, mobile operators could also combine spectrum from low frequency bands (such as the 800MHz band and 700MHz

¹⁶ Carrier Aggregation Technology can also be used to aggregate non-contiguous spectrum blocks within the same frequency band.

band if it is available for mobile services) in order to form a 20MHz high-speed LTE carrier. An illustration of this is shown in Figure 3-2. This aggregation of low frequency spectrum would enable the highest-speed LTE services to be deployed across the mobile operator's entire network footprint (including less populated areas) to complement the high-speed coverage in more populated areas that is provided using a higher frequency band such as the 1800MHz band or the 2.6GHz band. As 900MHz spectrum also becomes available for re-farming to LTE in the longer-term, spectrum in this band could also be combined with spectrum in the 700MHz and 800MHz bands to form an even bigger virtual carrier (e.g. 2x30MHz, as also shown in Figure 3-2).

Figure 3-2: Potential aggregation of 700MHz, 800MHz and 900MHz carriers



The provision of the highest mobile broadband data rates in less populated regions is likely to be a key mechanism for the achievement of the European Digital Agenda target of ensuring that all European citizens have access to Internet speeds above 30Mbps by 2020¹⁷. The aggregation of spectrum across different low frequency bands is, in turn, key to enabling such high-speed services to be provided in less populated areas on an economic basis – whilst use of high frequencies (such as 2.6GHz) would provide the required peak data rates, the coverage provided by each base station would be significantly smaller than the case where low frequency bands are used – and therefore the numbers of households covered and revenue generated from each base station using high frequencies would be considerably lower than through the use of low frequency spectrum.

As well as combining spectrum in paired spectrum bands, CAT can also be used to combine paired spectrum with unpaired spectrum. The objective of such an approach is to use the unpaired spectrum to boost downlink speeds in view of the asymmetrical consumer requirements when using the Internet which results in a requirement for higher downlink peak data rates and significantly higher downlink capacity than uplink data rates/capacity.

In the USA AT&T is seeking to combine its unpaired spectrum holdings in the 700MHz band (which were purchased from Qualcomm in 2011) with its AWS (1700/2100MHz) spectrum holdings to boost downlink speeds and capacity. In Europe a draft ECC Decision¹⁸ has been prepared for harmonising the 1452-1492MHz band for supplemental downlinks. It is theoretically possible that the 2GHz unpaired spectrum bands under consideration in this study could also be useful for supplemental downlinks, however, as we discuss in Section 4.2, such use is appearing unlikely.

¹⁷ See 'Digital Agenda for Europe: key initiatives', MEMO/10/200, European Commission, 19 May 2010.

¹⁸ See 'A major step towards the harmonised use of the band 1452-1492MHz: Mobile Supplemental Downlink is the way ahead', Electronic Communications Committee newsletter, December 2012.

4 2GHz band

In this section we discuss the current usage and future potential usage of the 2GHz band – which, as discussed in Section 2.1, comprises the 2.1GHz paired band (1920-1980MHz paired with 2110-2170MHz), the 1900MHz unpaired band (1900-1920MHz) and the 2.0GHz unpaired band (2010-2025MHz).

In 1999, the European Parliament and the Council adopted the UMTS Decision¹⁹ under which Member States were required to make the above bands available for UMTS services by 1 January 2002. There has been a significant difference in the subsequent usage of the paired and unpaired spectrum bands and consequently we consider the paired and unpaired spectrum separately in this section. Section 4.1 discusses the current and likely future use of the 2.1GHz paired spectrum whilst Section 4.2 discusses the current and potential future uses of the 1900MHz and 2GHz unpaired bands.

4.1 2.1GHz paired spectrum

In line with the UMTS Decision, European Community Member States assigned the 2.1GHz paired spectrum for use for the deployment of UMTS technology. Licences were awarded to between 3 and 6 organisations in each country typically comprising a mixture of 2G network operators and new market entrant(s). 3G (UMTS) networks were subsequently deployed in each country and the 2.1GHz paired band became (and remains) the main band for providing 3G services. Not all new entrants subsequently launched services and in such cases the companies were acquired by competing operators or the spectrum was returned to national regulators who subsequently re-assigned it through a new award process.

Following the introduction of the initial versions of UMTS technology in this band, enhanced versions of 3G including HSPA, HSPA+ and DC-HSPA+ have subsequently been deployed in the band. Looking forward, as discussed in Section 3, it is anticipated that the 2.1GHz band will continue to be used for 3G technology in the short-term, however in the medium to long-term, it is expected that 4G (LTE) and LTE-Advanced technology will also be deployed in this band as subscribers migrate from 3G to 4G.

Since the UMTS Decision, the European Union has moved to adopt a technology neutral licensing policy for new bands as well as removing technology restrictions in previously assigned bands. As part of this process, in November 2012 the European Commission issued a Decision²⁰ which requires Member States, by 30 June 2014, to modify the technical usage parameters specified in the licences for the 2.1GHz paired spectrum to make them more flexible – in practical terms this means that the band can be used for technologies other than UMTS - such as LTE.

In addition to the resolution of any regulatory constraints, for the 2.1GHz band to be used for LTE, network equipment and consumer terminal equipment operating in this band needs to be available. The 2.1GHz paired band is one of the bands identified for LTE deployment in the 3GPP specifications (in fact

¹⁹ See ‘*Decision 128/1999/EC on the coordinated introduction of a third-generation mobile and wireless communications systems (UMTS) in the Community*’, published in the Official Journal of the European Community on 22 March 1999.

²⁰ See ‘*Commission Implementing Decision 2012/688/EU of 5 November 2012 on the harmonisation of the frequency bands 1920-1980MHz and 2110-2170MHz for terrestrial systems capable of providing electronic communications services in the Union*’, published in the Official Journal of the European Union on 7 November 2012.

the band is referenced as “Band 1”) and so it is simply a matter of timing for equipment to become available on a widespread basis.

In a study²¹ undertaken for Ofcom in 2011/2012, Real Wireless noted in relation to use of the 2.1GHz paired band for 3G that:

“The 2100 MHz band is one of the most widely supported bands for mobile devices. This is based on the number of operator deployments of networks in this band with over 166 operators across Europe (including approximately 20 UMTS900 deployments in Europe) who have deployed HSPA networks. The GSA reported 78 around 3227 HSPA devices are now commercially available from over 264 suppliers with 2457 HSPA devices operating in this band.”

and, furthermore, that:

“European operators are focusing on enhancing services in 2.1 GHz spectrum to HSPA+ and DC-HSPA+ including Spain, Sweden, Italy and Portugal.”

By contrast, in relation to the use of the 2.1GHz paired band for LTE, Real Wireless noted that:

“There is currently no evidence of any European countries supporting LTE in this band. The contrary evidence from the GSA and GSMA suggests that European countries are predominantly planning to deploy LTE in new spectrum such as 2.6 GHz rather than 2100 MHz

However, NTT DoCoMo has deployed LTE in the Japanese version of this band and some analysts suggest this should be the global roaming band for LTE.”

Based on our extensive work with European mobile operators preparing for spectrum auctions, Aetha also believes that the primary focus of mobile operators in respect of the 2.1GHz band will in the short-term remain on the deployment of advanced versions of HSPA technology, such as DC-HSPA+, rather than LTE. The 2.1GHz spectrum will primarily be needed to provide sufficient network capacity to support 3G subscribers, whose numbers are rapidly increasing as a consequence of the widespread adoption of smartphones, and it is not likely to be until 2020 that the majority of 3G subscribers will have migrated over to LTE networks enabling the spectrum that is used for the provision of 3G services (both the 2.1GHz paired band and any 900MHz spectrum used for the deployment of UMTS) to be migrated over to LTE.

As European operators are mainly focusing on the 800MHz, 1800MHz and 2.6GHz bands for their LTE roll-outs, LTE devices that operate in the 2.1GHz band are more limited in numbers. In February 2013 the Global mobile Suppliers Association (GSA) reported²² that 107 devices were available that operated in the 2.1GHz paired band – compared with 137 devices operating in the 800MHz band, 153 devices operating in the 1800MHz band and 180 devices in the 2.6GHz band. However it is also worth noting that inclusion of 2.1GHz paired band LTE capability in new devices is becoming increasingly popular – in November 2012, the GSA reported that only 72 devices were available that operated in the 2.1GHz paired band (i.e. there has been a growth of almost 50% of the number of devices in just 3 months), whilst other frequency bands saw device availability growth rates of approximately 15%-20% over the same period. It is also worth

²¹ See ‘*The timing of the consumer and operator features available from HSPA and LTE*’, produced by Real Wireless on behalf of Ofcom, version 1.01, January 2012.

²² See ‘*REPORT: Status of the LTE Ecosystem*’, Global mobile Suppliers Association, 31 January 2013.

noting that the European/Asian version of the iPhone 5 does support LTE in the 2.1GHz band (as well as in the 1800MHz band).

In the Netherlands, the three larger mobile operators (KPN, T-Mobile and Vodafone) each currently hold 2x20MHz of spectrum in the 2.1GHz paired band. This allows them to deploy a maximum of four UMTS carriers in the band (in each sector at each base station site). However Aetha has anecdotally heard that this can be challenging as the UMTS specifications were originally prepared on the basis that an individual mobile operator would have a maximum of three UMTS carriers in any one frequency band. Consequently not all equipment has been designed to work with more than three UMTS carriers in a single band. If this is a major challenge, it is possible that each of the three larger mobile operators could be interested in deploying LTE in the ‘spare’ spectrum (not utilised for UMTS) in the 2.1GHz paired band. Offset against this, however, is that in the initial stages, only 2x5MHz of spectrum would be available for LTE in this band, and the main benefits of LTE are realised with carrier sizes of 10MHz or greater (for this reason 800MHz spectrum auctions have mostly resulted in each winner acquiring 2x10MHz of spectrum and one or more losers acquiring no spectrum at all²³ - rather than a mixture of operators acquiring 2x10MHz and 2x5MHz of spectrum). Consequently, deployment of LTE in the 2.1GHz paired band may not be attractive to the three larger mobile operators in the short-term compared to the use of other frequency bands such as 1800MHz and 2.6GHz. However, in the medium-term, capacity constraints on the LTE network will mean that LTE deployment in the 2.1GHz paired band becomes attractive. It is possible that if the three larger mobile operators were to retain their existing 2.1GHz spectrum holdings, each operator may wish to deploy a 10MHz LTE carrier in the 2.1GHz paired band towards the end of the current decade, whilst also retaining 2x10MHz of spectrum in the band for use for 3G services.

Tele2 acquired 2x10MHz of spectrum in the 800MHz band in the recent multi-band auction, supplementing the 2x20MHz of paired spectrum that it won in the 2.6GHz auction that was held in 2010. Tele2 has indicated that it expects to launch LTE services with the deployment of 4000 sites by the end of 2013²⁴. Tele2 has previously been operating as an MVNO and has an agreement with T-Mobile for wholesale access to T-Mobile’s 2G and 3G networks. Tele2 may be interested in acquiring 2.1GHz paired spectrum to provide additional LTE network capacity in the medium to long-term. There is also a possibility that Tele2 may be interested in acquiring 2.1GHz spectrum for deploying 3G technology in the short-term – this is because the incremental cost of adding 3G compatible equipment to Tele2’s base stations will be relatively modest and this deployment could reduce the costs Tele2 pays to other mobile operators for 3G roaming services.

ZUM (joint venture of Ziggo and UPC Netherlands) could also benefit from the acquisition of 2.1GHz spectrum for similar reasons. Ziggo acquired 2x20MHz of 2.6GHz spectrum in the 2010 auction, but was unsuccessful in acquiring any 800MHz spectrum in the 2012 multi-band auction. Ziggo launched mobile services as an MVNO (purchasing wholesale services from Vodafone) in 2010 and has been promoting the use of its customers’ WiFi routers to create public hotspots²⁵. It is not entirely clear what ZUM’s future network deployment plans are following the company’s recent failure to acquire 800MHz spectrum. One option could be for ZUM to utilise its 2.6GHz spectrum to build up an extensive footprint of ‘mini base stations’ by incorporating LTE femtocell technology in its WiFi modem/routers. Another option could be to deploy a conventional macro-cellular network in urban areas. If ZUM plans to deploy a macro-network

²³ This was also the case in the recent multi-band auction in the Netherlands.

²⁴ ‘Tele2 AB – Investing for the future’, research note prepared by Nomura International plc, 7 February 2013.

²⁵ See <https://www.ziggo.com/en/about-ziggo/products-and-services/ziggo-hotspots/> for further details.

utilising its 2.6GHz spectrum, then the incremental cost of also deploying LTE equipment (or possibly even 3G equipment) utilising 2.1GHz paired spectrum is likely to be modest, however if ZUM is not planning to deploy a network of base stations, then it is unlikely to have any interest in the 2.1GHz paired spectrum.

It is possible that the 2.1GHz band may be of interest in 2017 to an organisation contemplating entering the market as a mobile operator (i.e. a new market entrant) as a means of deploying LTE technology, particularly since it is likely that almost all of the European LTE devices launching at this time will support LTE in the 2.1GHz paired band. However we believe such interest is unlikely as Aetha's business case modelling work has shown that it is difficult to make a positive business case for new market entry in countries where the penetration of mobile devices exceeds 100% of the population – the exceptions where a positive business case can be made are for cable operators and other fixed operators without an existing mobile network business, who are able to utilise their existing customer relationships for directly marketing quad-play and fixed/mobile converged packages to consumers. Given that the two main cable operators and the main fixed operators in the Netherlands already have spectrum and that there are likely to be four (potentially five) competing mobile network operators in the country at the time of a future auction of spectrum, we believe it is highly unlikely that a viable case can be made for another mobile network operator.

In summary, the plans of the most likely acquirers of the 2.1GHz paired spectrum (KPN, T-Mobile, Tele2, Vodafone and possibly also ZUM) appear to be in line with the Ministry proceeding with its preparations for the award of the spectrum. This would provide the certainty of tenure that such organisations would seek in respect of making investments in LTE equipment for use in the band.

4.2 Unpaired bands (1900MHz and 2GHz)

As discussed in the introduction to this section, the 1900MHz and 2.0GHz unpaired bands were part of the UMTS Decision and it was intended that these bands would be used for the provision of 3G mobile technologies using Time Division Duplex (TDD), where the uplink and downlink signals occur in different timeslots rather than in separate frequency bands as is the case for Frequency Division Duplex systems. The principal advantage of the use of TDD technologies is that a greater proportion of the timeslots (and hence the underlying spectrum resource) can be dedicated to the downlink which better suits the asymmetric nature of Internet traffic.




The 1900MHz unpaired band was awarded in most European countries on a licensed basis, typically in combination with the 2.1GHz paired spectrum blocks. In the Netherlands, KPN, T-Mobile and Vodafone each have had a 5MHz assignment in this band (which is due to expire at the end of December 2016). Additionally, T-Mobile acquired a further 4.9MHz of spectrum in this band as part of the recent multi-band auction (the licence for this assignment is also due to expire at the end of December 2016).

Many countries planned to make the 2.0GHz unpaired band available on a licence-exempt basis, whilst other countries licensed this spectrum to specific organisations – as for the 1900MHz unpaired spectrum. In the Netherlands T-Mobile has a long-standing 5MHz assignment in this band (which is due to expire at the end of December 2016). Again, T-Mobile acquired a further 9.7MHz of spectrum in the band as part of the recent multi-band auction (the licence for this assignment is also due to expire at the end of December 2016).

TDD technology did not receive much interest/take-up from European mobile operators and as a consequence such technologies were mainly a niche play and mostly adopted in other parts of the world.

Figure 4-1 illustrates some of the TDD technologies that were available in the early part of the 2000-2010 decade. However, as a consequence of the limited take-up, over time interest in these technologies diminished and both the 1900MHz and 2.0GHz unpaired bands remained unutilised²⁶ in most European countries partially as a consequence of the lack of compatible equipment in these bands.

Figure 4-1:
Illustration of niche Time Division Duplex technologies available in 2004

| |  |  |  |
|-----------------------------|---|--|---|
| Commercial launch | 2003 | 2003 | 2003 |
| Spectrum requirement | 5MHz (TDD) unpaired spectrum | 5MHz (TDD) unpaired spectrum | 5, 6, 10 and 12MHz (TDD) unpaired spectrum |
| Deployment | Australia, China, Japan, Malaysia, South Korea, Thailand | South Korea, Ireland, USA | Japan, Malaysia, New Zealand, UK, USA |

In view of the limited interest in and usage of the unpaired 1900MHz and 2.0GHz bands for mobile services to-date, the European Commission decided to separate its proposals for the 2.1GHz paired band from the unpaired bands. As discussed earlier, in November 2012 the European Commission published its Decision²⁰ to remove unnecessary technology constraints on the use of the 2.1GHz paired band. As part of this Decision, the European Commission indicated that further work would need to be undertaken on the technical usage characteristics to be applied to the unpaired 1900MHz and unpaired 2.0GHz bands²⁷ and it would not be appropriate to delay the removal of restrictions on the 2.1GHz paired band whilst this additional work is undertaken given the unpaired bands remain largely unused.

In October 2012, the European Union's Radio Spectrum Committee^{28, 29} approved a new mandate³⁰ to CEPT³¹ to develop technical conditions for the 1900MHz and 2.0GHz bands to take account of a wide

²⁶ We understand that some specialist equipment for programme making and special events (e.g. wireless video cameras) are able to operate in the 2.0GHz unpaired band but are not aware of the degree of use of the band for this purpose across Europe.

²⁷ More restrictive conditions are required in the unpaired bands in order to protect mobile services using the 2.1GHz paired band and also ensure the co-existence of multiple TDD networks in the unpaired bands. See 'CEPT Report 39: Report from CEPT to the European Commission in response to the Mandate to develop least restrictive technical conditions for 2 GHz bands', CEPT European Communications Committee, 25 June 2010.

²⁸ The Radio Spectrum Committee (RSCOM) is a committee of Member States representatives. It approves EU spectrum harmonisation measures (proposed by the European Commission) under delegated power from the Council of the EU (gathering of governments of the 27 countries in the EU representing the individual Member States). These spectrum harmonisation measures then lead to a Commission Decision which has immediate validity.

²⁹ See 'Radio Spectrum Policy Group: Commission activities related to radio spectrum policy', Document RSPG12-437, European Commission, 25 October 2012.

³⁰ See 'Draft Mandate to CEPT to undertake studies on the harmonised technical conditions for the 1900-1920 MHz and 2010-2025 MHz frequency bands in the EU', Document RSCOM12-17 rev 3, European Commission, 10 September 2012.

³¹ European Conference of Postal and Telecommunications Administrations – see www.cept.org for further details.

range of potential uses of the band other than for mobile communications networks. Specifically the mandate has identified a shortlist of potential harmonised uses of the 2GHz unpaired bands to be given priority, namely:

- Public Protection and Disaster Relief (PPDR) – with preference to ad-hoc (non-permanent) PPDR networks
- Programme making and special events – preferably for use by wireless cameras
- Short range devices (SRD), preferably for improving energy saving and/or energy efficiency
- Additional spectrum for the Digital European Cordless Telephone (DECT) – including innovative applications such as machine to machine, preferably in the 1900MHz band
- Broadband Direct Air-to-Ground Communications (BDA2GC), preferably in a paired spectrum arrangement.

The mandate also notes that some of these applications are temporary or local in nature and therefore there should be scope for shared use of the spectrum between different applications.

The European Commission requires the CEPT to provide a final report by November 2014; however initial results should be available from the end of 2013.

It therefore appears unlikely that the 2GHz unpaired bands will continue to be harmonised for mobile broadband use in the longer-term. However this is not certain as interest in TDD technologies has recently increased – particularly in respect of a TDD variant of LTE technology. Most interest in LTE TDD solutions has been in respect of the 2.6GHz unpaired band, the 2.3GHz band and the 3.5GHz band which provide significantly greater amounts of spectrum than the amount available in the 2GHz unpaired bands.

One other possibility for continuing mobile services use of the band would be to use one or both of the unpaired 2GHz bands to provide supplemental downlink spectrum when put together with another paired spectrum band. However such supplemental downlink pairs need to be included in the 3GPP specifications if equipment is to be made supporting the respective pairs. At present interest in Europe is focused on combining the 1452-1492MHz band³² with paired spectrum.

Whilst, in theory, the Netherlands could continue allowing use of the 2.0GHz unpaired bands for mobile communications systems, provided usage at border areas was constrained so as not to exceed any interference limits specified in the new usage parameters developed by CEPT for the band, however in practice (i) new uses of the 2GHz unpaired bands identified at the European level are likely to also be valuable uses in the Netherlands and (ii) mobile equipment manufacturers are unlikely to be willing to develop and maintain equipment for the 2GHz unpaired bands that is only for use in the Netherlands. In reality the Netherlands should therefore work with the rest of Europe to identify new uses of these bands.

In summary it appears that the Ministry should await the initial results of the studies undertaken by CEPT on the compatibility of new potential uses of the 2GHz band before starting to make decisions about the award of the spectrum. It seems highly likely that the spectrum will no longer be harmonised with technical parameters that are primarily compatible with use of the band for mobile technology deployment and

³² See ‘1000x: More Spectrum – Especially for Small Cells’, Qualcomm Inc, October 2012.

therefore there is no longer a case for awarding the 1900MHz unpaired and 2.0GHz unpaired spectrum in the same process used for the award of the 2.1GHz paired spectrum.

Given the above situation, one question that has been raised is “Why did T-Mobile acquire 5MHz of spectrum in the 1900MHz unpaired band and 10MHz of spectrum in the 2.0GHz unpaired band in the recent multi-band auction, given that the reserve price of this spectrum was EUR590 000 and the licences are only of four years duration?”

The first answer to this question is that it is possible that T-Mobile may have paid less (and, potentially, considerably less) than the reserve price of the spectrum. Bids were made for packages of spectrum in the auction – such bids have to be greater than the sum of the reserve price of all the spectrum in the package, however an increase in the bidding level to account for an incremental lot (on top of another package of spectrum) does not have to be equal to/greater than the reserve price for the incremental lot – the requirement is that the total bid value is greater than the total reserve prices of all the lots in the package. Consequently one auction tactic adopted by bidders is to seek to acquire relatively low-value lots of spectrum at a very low incremental cost to the main package(s) of spectrum that they seek.

The second answer to the question is that bidding on this band may also have been part of the auction tactics:

- bidding on this spectrum may have provided T-Mobile with useful flexibility in subsequent stages of the auction (e.g. by maintaining activity points/eligibility level³³)
- acquiring this spectrum at relatively low cost could also be useful for presentational reasons at the end of the auction (e.g. when comparing the total amount of spectrum acquired in the auction with competitors or to compare the normalised price paid for spectrum (e.g. in per MHz terms or per MHz per pop terms) with the company’s competitors).

Thirdly, T-Mobile may well have a valuable use for the unpaired spectrum that we are not aware of. This may be in relation to using the spectrum for mobile service provision or it may be for a completely different use, subject to the compliance with the current regulations governing use of the spectrum.

³³ See ‘Regulation of the Dutch Ministry of Economic Affairs, Agriculture and Innovation dated January 6th, 2012, no. WJZ/10146523, to establish the application and auction procedure for licences for the frequency spectrum in the 800, 900 and 1800 MHz bands for mobile communication applications (Regulation regarding the application and auction procedure for 800, 900 and 1800 MHz licences)’.

5 700MHz band

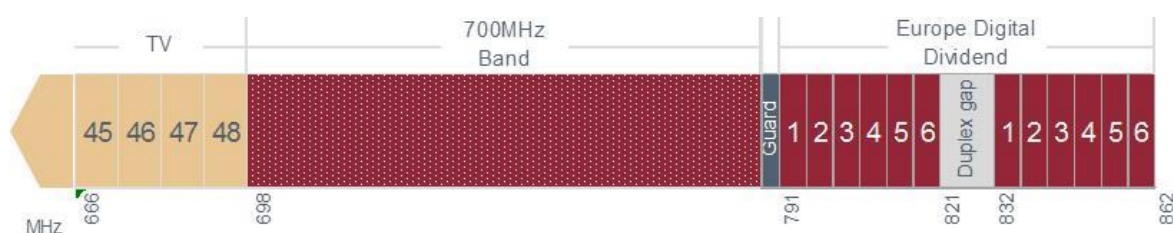
In this section we discuss the current use of the 700MHz band and background to consideration of its use for mobile communications services (Section 5.1) and review the current status of European Union discussions on this topic (Section 5.2). We then discuss the potential bandplans under consideration for this band (Section 5.3) and conclude with a discussion of the likely timing of availability of this band for mobile services (Section 5.4).

5.1 Background

The 694-790MHz (700MHz) band is currently used for terrestrial television broadcasting across the European Union. During the World Radiocommunications Conference in 2012 (WRC-12), an agreement was reached (subject to final confirmation in WRC-15) to make a Primary allocation to wireless broadband alongside broadcast services in the 694-790MHz³⁴ band from 2015 across the whole of ITU Region 1 (covering Europe, the Middle East and Africa). One of the main reasons for this decision was to potentially align use of these frequencies with other regions of the world (ITU Regions 2 and 3) – specifically frequencies in this band are currently being used in North America and are expected to be used in South America and Asia for the provision of mobile broadband services using LTE technology. The 700MHz band in these regions represents the ‘digital dividend’ that was made available for mobile communications services (analogous to the 800MHz band that was created across Europe to support the deployment of advanced mobile technologies such as LTE). At WRC012, Middle East and African countries were keen to facilitate the creation of a 700MHz band for mobile services so that they could benefit from the economies of scale arising from equipment that is developed for the large populations in Asia and the Americas.

An illustration of the 700MHz band and its adjacency to the existing 800MHz band is shown in Figure 5-1 below.

Figure 5-1: Overview of proposed 700MHz band and positioning relative to 800MHz band



The decision at WRC-12 has led to considerable interest being raised from the mobile community across Europe in respect of the feasibility of creating a 700MHz band for mobile services. A new low frequency band suitable for the deployment of mobile broadband services is seen as being important to the mobile industry in view of:

- the forecast rapid growth in mobile data traffic levels (a 5 to 10 fold increase is expected in the coming 10 years)

³⁴ Note that the lower edge of this band is to be confirmed as part of WRC-15.

- the need for low frequency spectrum to carry network traffic that is only within ‘reach’ of low frequencies which are able to propagate through walls and cover extended regions of rural areas (typically 30%-50% of a mobile operator’s traffic needs to be carried over low frequency spectrum)
- the need for additional low frequency spectrum to maintain competition in many European markets – typically mobile operators seek a minimum of 2x10MHz of spectrum in the 800MHz band, however there is only a total of 2x30MHz of spectrum in this band leaving room for only three operators to have access to the 800MHz band. The 700MHz band would provide an opportunity for the ‘losing’ operators to acquire low frequency spectrum for LTE
- the key role for wireless broadband technologies in meeting the European Digital Agenda targets – particularly in respect of ensuring 100% availability of fast broadband (>30Mbps) services by 2020
- the introduction of Carrier Aggregation Technology which will support high-bandwidth carriers across multiple bands. For example, as discussed in Section 3.2, an LTE-Advanced carrier formed using spectrum from the 700MHz, 800MHz and 900MHz bands could be used to provide high-speed broadband services to rural communities.

The creation of a second mobile band for mobile services from UHF frequencies used for terrestrial television broadcasting will be considerably more challenging than the creation of the 800MHz band since the 800MHz band was created from the ‘dividend’³⁵ that arose as a result of migrating analogue television to digital technology. By contrast, the creation of the 700MHz band would result in the loss of approximately 30% of the remaining UHF spectrum used for television broadcasting and would therefore require changes to the broadcasting network infrastructure (e.g. use of single frequency networks in place of multi frequency networks, the deployment of new broadcasting sites operating at lower power levels, replacement of existing consumer digital television receivers with ones that are compatible with DVB-T2 technology and the MPEG-4 compression specification, a possible requirement for some consumers to replace/alter the direction that their rooftop aerials are facing) or potentially a reduction in the number of television channels that can be supported on the platform, as a result of the reduction in the amount of spectrum available for broadcasting. Consequently the broadcast community have raised significant concerns in relation to potential creation of the 700MHz band for mobile services.

We understand that five national Digital Terrestrial Television (DTT) multiplexes are currently deployed in the Netherlands and there are no (current) plans to deploy any additional multiplexes, though it is anticipated that HDTV will be introduced on the DTT platform³⁶.

³⁵ Such a ‘dividend’ arises as approximately eight digital television channels can be transmitted using the spectrum that was previously required to transmit one analogue terrestrial television channel. Consequently the migration to digital television and switch-off of analogue television supported a significant increase in the number of television channels available on the platform as well as allowing spectrum to be made available for mobile services (the 800MHz band).

³⁶ Source: Response submitted by the Netherlands to a ‘*Questionnaire on: The long term spectrum requirements for television broadcasting in the European Union including the number of TV services, HDTV, interactive services, mobility requirements and the possible introduction of High Definition Television*’ issued by the Radio Spectrum Policy Group. A copy of the response is available on the web-site: <http://rspg.groups.eu.int/>

5.2 European Union discussions

Decisions on the future use of the 700MHz band need to be taken at a European level. This is primarily because of the nature of television broadcasting which utilises high power transmissions which travel significant distances across border regions. Thus a country cannot individually make a decision to change use of the 700MHz frequencies from television broadcasting to mobile services as broadcast signals from neighbouring countries could prevent the use for mobile services in significant regions of the country. Similar issues applied in the case of the 800MHz, leading to the need for a decision to be made at the European level. The need for equipment economies of scale was a further key factor in taking a pan-European approach to the creation of the 800MHz band – this is arguably less critical in this case in view of the likely use of the 700MHz band for LTE in other regions of the world – though this is dependent on Europe adopting the same bandplan and technical usage characteristics in the band as the other regions – this is discussed further in Section 5.3 below.

In order to stimulate a Europe-wide debate on the future of the 700MHz band, on 1 June 2012, the European Commission submitted a discussion paper³⁷ to the Radio Spectrum Policy Group (RSPG)³⁸ on the future use of the 700MHz band in the EU which considered four options:

- *Maintaining use of the whole of the band for terrestrial television* – noting that this could hinder prospects for broadband growth
- *Exclusive spectrum use for wireless broadband (re-allocation)* – noting that this would require extensive modifications to the existing digital terrestrial television (DTT) infrastructure – in particular broadcast operators would need to deploy more spectrally efficient technologies (e.g. DVB-T2, MPEG-4) and modify existing network architectures (e.g. migrate to single frequency networks - SFNs)
- *Shared (broadcasting-mobile) spectrum use* – noting that this could be difficult in view of different power transmission levels
- *Convergence mobile-broadcasting* – incorporating the use of a dense network of sites using broadcast technology (e.g. MBMS).

At the time, the European Commission indicated that it was aiming for a common European approach to be decided fairly quickly.

Following the submission of this paper, the RSPG has been considering the 700MHz band as part of its activities in relation to identifying solutions to meet the future demand for spectrum to support the growth in wireless broadband services - for which the RSPG has set-up a dedicated Working Group. The Working Group has been tasked with providing a draft Opinion for review at the RSPG's next meeting on 20 February (which will then be open to public consultation) and is also planning to draft a report examining

³⁷ See 'Commission services discussion paper on the future use of the 700 MHz band in the European Union', European Commission submission to Radio Spectrum Policy Group, Document RSPG12-425.

³⁸ The Radio Spectrum Policy Group (RSPG) is an advisory group assisting the European Commission (and, on request, also the Parliament and Council) with the development of spectrum management policy. The RSPG comprises senior representatives from Member States (typically from the national regulator and/or ministry responsible for communications) and a representative from the EC.

several potential frequency bands in more detail, including the 700MHz band, which would be made available to the RSPG's meeting in June 2013.

In July 2012, the RSPG's Working Group issued a survey to Member States (and industry groups) on the long-term spectrum requirements for television broadcasting. The responses to this survey³⁹ showed that almost all countries were planning to deploy additional multiplexes and offer new services (including High Definition Television and 3D television).

As discussed in Section 5.1, the response of the Netherlands indicated that there are no (current) plans to deploy any additional multiplexes, though it is anticipated that HDTV will be introduced on the DTT platform. The response also indicated that *“a migration from high power/high tower network towards low-power type of MFN networks enhances possibilities and will greatly increase spectral efficiency.”* In relation to the evolution of the DTT platform towards delivering audio-visual services also to mobile terminals, the Netherlands response noted *“Yes, the amount of both linear and non-linear video services is growing in the mobile network. A combined network based on low-power technology may be used to cope with this increase in data services. It is still an open question whether all broadcasting services will and can be delivered through the mobile network, a combined network, or that here remains a need for a separate DTT network.”*

We note that the response from the Netherlands was much more “balanced” on the potential convergence of broadcast networks and mobile networks in the future. This may be a consequence of the fact that only 22% of households in the Netherlands receive television services via the terrestrial platform compared to close to 100% in some other countries (e.g. Spain and Italy)⁴⁰. Please note that the 22% includes both households for which DTT is the means through which the primary television set in the household receives service as well as households where DTT is used to provide service to secondary television sets. 801 000 homes subscribed to KPN's Digitenne service⁴¹ as the primary means of television viewing in April 2012 – a penetration rate of approximately 7.6% of households.

A further RSPG activity includes the preparation of a report by the Working Group on EU Assistance in bilateral coordination on a spectrum coordination approach for broadcasting in the case of a reallocation of the 700MHz band. The draft version of this report⁴² highlighted the complexity that would be involved in re-planning the band and recommended that a bilateral/multilateral negotiation approach be adopted (rather than a re-run of the GE-06 Regional Conference approach). The report also indicated that a period of around three years would be needed to reach the cross border agreements required and that the main part of this process cannot begin until WRC-15 has made a decision about the 700MHz band allocation and the EU has made decisions on the future use of the band. Finally the report noted that coordination of the dates

³⁹ See ‘Summary of responses to the recent Questionnaire on: The long term spectrum requirements for television broadcasting in the European Union including the number of TV services, HDTV, interactive services, mobility requirements and the possible introduction of High Definition Television’ and individual survey responses on the RSPG's web-site: <http://rspg.groups.eu.int/>

⁴⁰ Source: ‘How European households receive TV?’, Eurobarometer 362, E-Communications household survey conducted by TNS Opinion & Social on behalf of the Directorate-General Information Society and Media of the European Commission, July 2011.

⁴¹ See <http://www.digitaltveurope.net/23449/kpn-adds-iptv-subscribers-but-digitenne-continues-to-decline/> for further details.

⁴² See ‘Draft RSPG Report on proposed spectrum coordination approach for broadcasting in the case of a reallocation of the 700MHz band’, Document RSPG12-433, 25 October 2012.

of introduction of mobile services in the 700MHz band would be required in order to avoid interference between mobile networks and broadcasting networks.

The European Commission is planning to issue a Communication on an Action Plan for Wireless Communications⁴³ in the next few months. It is intended that this will include a discussion of the potential importance of the 700MHz band and emphasise the need for an EU level political agreement on the future use of the band to be reached. Furthermore, the Action Plan should outline the next steps that are envisaged at EU level and in the Member States to take this initiative forward. Giving a hint of part of the possible contents of the Action Plan, in a speech⁴⁴ to the RSPG on 20 February 2013, Vice-President Kroes announced that the European Commission plans to set-up a High-Level Group from the mobile and broadcasting industries to work on identifying a long-term solution for 700MHz band. The Group will consider both political and technical aspects, considering the latest market and technological trends including the convergence of services. The aim will be to achieve a political agreement and provide regulatory certainty. Further details (e.g. on the target timing for reaching agreement) have not been published at this stage.

The European Commission has also drafted a Mandate to CEPT⁴⁵ to develop technical conditions for the introduction of wireless broadband in the 694-790MHz band. In doing so, the European Commission emphasised that this mandate was without prejudice to any future political decision at EU level on the future use of the 700MHz band in the EU – i.e. it is seeking to split the political decision from the technical work that is needed to identify the usage conditions for a future 700MHz mobile band, including the issue of an appropriate bandplan (which we discuss in the following section). The latest version of the draft Mandate is due to be discussed at the next Radio Spectrum Committee meeting which is being held on 20 and 21 March 2013 - we currently understand that some Member States (e.g. the French administration) may raise concerns about the contents of the draft Mandate.

At the time of writing, it is therefore not entirely clear how European discussions on the 700MHz band will move forward and when a final political decision on whether or not to create a pan-European 700MHz band for mobile services will be made. This may be clarified in the European Commission's upcoming Action Plan for Wireless Communications.

5.3 Potential bandplans

In addition to the political decision on whether to make the 700MHz band available for electronic communications services, and if so, by when, the technical usage conditions applying to the band in the event that it were made available for electronic communications services also need to be specified. The European Commission is aiming to separate this technical discussion from the overall political decision and, as discussed above, has drafted a mandate for issue to CEPT to develop the technical parameters for the 700MHz band, reporting back to the European Commission in late 2013/early 2014.

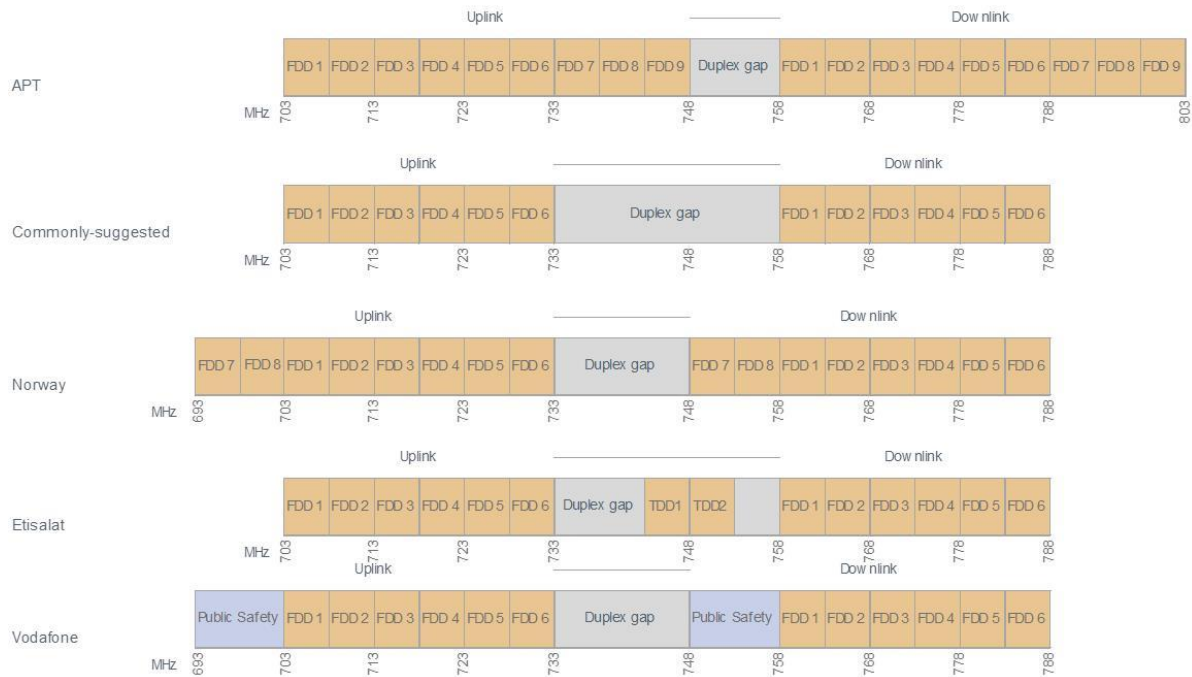
⁴³ See 'Roadmap: Action Plan on Wireless Communications for a Connected Europe', European Commission DG Connect B4, February 2013.

⁴⁴ See 'Thinking European, and winning the wireless race', Speech by Neelie Kroes, Vice-President of the European Commission responsible for the Digital Agenda, delivered at the Radio Spectrum Policy Group plenary meeting, 20 February 2013.

⁴⁵ See 'Draft Mandate to CEPT to develop harmonised technical conditions for the 694-790MHz ('700MHz') frequency band in the EU for the provision of wireless broadband', Document RSCOM12-37, European Commission, December 2012.

One of the most critical aspects of the technical conditions is the bandplan to be adopted for the 700MHz band. Some arguments have been made for utilising an unpaired bandplan as this would allow the band to be used as a supplemental downlink by combining it with a paired band (e.g. the 800MHz) in order to provide a significant boost to the peak data rates and network capacity on the downlink, aligning it with the asymmetric nature of Internet traffic – particularly video applications which are likely to be the main driver of growth of traffic on LTE networks. However it is more likely that a paired configuration will be chosen, given this is the nature of use of the 700MHz band in other parts of the world. Figure 5-2 below illustrates several of the proposed paired bandplan configurations that have been proposed.

Figure 5-2: Proposed band-plans for the 700MHz band (examples)



Aetha expects that the final bandplan that is selected will be chosen so as to align with the Asia Pacific Telecommunity’s 700MHz bandplan as shown in Figure 5-3 below. This is the bandplan which is likely to be adopted across Asia, Central and South America and parts of the Middle East and Sub-Saharan Africa. Alignment with this plan would allow Europe to benefit from the economies of scale deriving from equipment that is produced for these large markets

Figure 5-3: Potential alignment of European 700MHz bandplan with APT 700MHz bandplan and European 800MHz bandplan



5.4 Timing of availability of band

In addition to the uncertainty over the political process for making a decision on whether the 700MHz band will be made available for electronic communications services and the timing for that decision to be made, there is also considerable uncertainty over the timing that the new 700MHz band usage conditions would be implemented across Europe i.e. the date from which the 700MHz band can be used for the deployment of mobile technologies.

As discussed in Section 5.2, countries cannot make unilateral decisions on this issue because of the scope for significant cross-border interference between broadcast television and mobile broadband services. Consensus therefore also needs to be reached on a co-ordinated European timetable for the introduction of mobile services in the band.

The Finland Government has indicated that it would like the 700MHz band to be made available for mobile services from 2017⁴⁶. Ofcom in the UK has indicated that “*the earliest date this [change of use at 700MHz] could be achieved is 2018, providing there is sufficient agreement in Europe.*”⁴⁷ As discussed in Section 5.2, the RSPG has published a draft report by a Working Group looking at the issue of internationally co-ordinating the clearance of the 700MHz band from broadcast television which indicated that a period of around three years would be needed to negotiate and achieve the cross border agreements required and that the main part of this process cannot begin until WRC-15 has made a decision about the 700MHz band allocation and the EU has made decisions on the future use of the band.

We expect that further time will be required to fully implement the new co-ordinated frequency plan across Europe and therefore expect that the earliest possible date for pan-European availability of the 700MHz band for electronic communications services is 2020. It is possible that some countries on the western and northern borders of the European Union may be able to make the band available sooner than this in view of the reduced scope for international interference and therefore greater availability of frequencies in their countries. It is also possible that countries on the eastern border of the European Union may face further

⁴⁶ See ‘*Minister Kiuru calls for legislative amendments to prepare for the uptake of 700 MHz band for broadband use*’, Press release from the Ministry of Transport and Communications in Finland, 25 January 2013.

⁴⁷ See ‘*Securing long term benefits from scarce low frequency spectrum: UHF strategy statement*’, Ofcom, 16 November 2012.

delays in making the band available for mobile broadband, as a result of continuing use of the band for broadcast television services by non-EU neighbouring countries (use of the 800MHz band for aeronautical radio-navigation services and broadcast television services in Russia and the Ukraine delayed the availability of the 800MHz band in several European Union countries – including Finland).

We note that it is also possible that an EU-wide agreement may not be reached. Different countries attach different levels of importance to the digital terrestrial television platform and it may prove to be impossible to reach a consensus decision to implement the 700MHz band across Europe. At the very least, it may take more years than expected for a decision to be reached. We note that the European decision-making process for the creation of the 800MHz band suddenly accelerated once Spain (unexpectedly) decided⁴⁸ to end its opposition to the creation of the band, which then rapidly led to other opponents (e.g. Italy) also changing their plans.

It is also possible that it may not be possible to reach Europe-wide agreement on the allocation of the 700MHz band to electronic communications services but that a subset group of countries may decide to proceed with this change. This will be very challenging to achieve as it would require that the countries deciding to move forward are geographically located next to each other in order to minimise interference issues. Furthermore this group of countries will not benefit from the full European economies of scale – though arguably this is less important for the 700MHz band if the APT bandplan is adopted in which case the European countries adopting the 700MHz band for mobile can benefit from the economies of scale generated in Asia and other regions of the world.

The timing of any decisions by Europe on this key issue is currently unclear; however the European Commission's forthcoming Action Plan for Wireless Communications⁴³ may provide clarity on this in the coming months.

⁴⁸ See 'GSMA welcomes Spanish Government proposal to release digital dividend spectrum for mobile use', GSM Association, 3 June 2009.

6 Benefits from and feasibility of combining awards

In this section we aggregate the results of our research on the 2GHz and 700MHz bands (as presented in Sections 4 and 5) and assess the feasibility of combining the awards of spectrum in both the 2GHz and 700MHz bands. In Section 6.1 we discuss whether there is an economic case (from the perspectives of potential users of the spectrum) for combining the awards. In Section 6.2 we discuss whether the timing of spectrum availability and optimum timing of award of the spectrum in each of the bands is conducive to a joint award process.

Please note that the discussion in this section focuses on the feasibility of combining the 2.1GHz paired spectrum award with the 700MHz spectrum award. The 1.9GHz unpaired band and the 2.0GHz unpaired band are not considered further in this section since, as discussed in Section 4.2, these bands are not likely to remain harmonised for mobile communications network deployment in the future and therefore there is no particular economic reason for the awards of these spectrum bands to be combined with the awards of bands that are likely to be used for the deployment of mobile technologies (such as the 2.1GHz and 700MHz band).

6.1 Economic case for combining awards

As discussed in Section 2, one key consideration in whether the award of the 2.1GHz paired and 700MHz bands should be combined is whether there are sufficiently strong linkages between the bands in respect of the business cases of potential users of the spectrum. This includes consideration of whether the bands are complementary in that the success of the business case for one band is strongly dependent on having spectrum holdings in the other band and also the degree to which the bands are close substitutes (the degree to which the bands are alternatives to each other) in which case there are likely to be benefits in awarding the bands together to avoid any artificial scarcity issues. In the remainder of this section we consider whether there are likely to be any complementary or substitution issues in respect of the two bands from the perspectives of the three larger mobile operators (KPN, T-Mobile and Vodafone), the two new mobile entrants (Tele2 and ZUM) and any potential new entrants.

In respect of the larger three mobile operators (KPN, T-Mobile and Vodafone):

- The 2.1GHz band is key for the continuation of the provision of 3G services to consumers and could be useful for deploying additional LTE capacity in urban areas in the medium to long-term.
- The 700MHz band would provide additional low frequency spectrum for the deployment of LTE services – which could be used to enhance data rates and network capacity in less populated regions and in respect of providing deep indoor coverage.
- There is no clear complementary relationship between the two bands in the case of these operators. The business cases for both bands are largely independent of each other.
- Likewise we have not identified a case where the 2.1GHz and 700MHz bands may be close substitutes to each other. Alternatives to the 2.1GHz band include extending the amount of 900MHz spectrum dedicated to 3G services in the short-term and use of the 1800MHz, 2.6GHz and higher frequency bands to provide long-term LTE capacity in urban areas. The closest alternatives to the 700MHz band are the 800MHz band and the 900MHz band. All three of the operators already hold 900MHz spectrum whilst only KPN and Vodafone hold 800MHz spectrum. In the case of T-Mobile, it is anticipated that the company will utilise its existing 1800MHz network grid (originally built for the deployment of the

coverage layer for GSM technology) to facilitate widespread deployment of LTE across the Netherlands.

In respect of Tele2:

- The 2.1GHz band could be useful in the medium to long-term to provide additional LTE capacity in urban areas.
- The 700MHz band could supplement the company's 800MHz spectrum providing enhanced data rates and additional network capacity in less populated regions/areas where deep indoor coverage is required.
- Given the differing uses of the two bands, it is not clear that the company's business plan for exploitation of one of the bands should be dependent on acquisition of the other band i.e. there is no particular complementary relationship between the bands.
- The two bands do not appear to be close substitutes to each other. Alternatives to the 2.1GHz band for Tele2 include use of other high frequency bands (existing 2.6GHz spectrum holdings and other bands that may become available in the future) to provide additional LTE network capacity in urban areas. The main alternative to the 700MHz band are the 800MHz and 900MHz bands – Tele2 holds 2x10MHz of 800MHz spectrum but no 900MHz spectrum.

In respect of ZUM, in the case where ZUM does plan to deploy network of macro-base stations utilising its existing 2.6GHz spectrum holdings:

- As for Tele2, the 2.1GHz band would be useful in the longer-term for providing additional LTE capacity in urban areas.
- The 700MHz band could be complementary to ZUM's existing 2.6GHz spectrum holdings as it would allow the company to extend network coverage to less populated regions as well as providing deeper indoor coverage
- Given the differing uses of the two bands, it is not clear how ZUM's business plan for exploitation of one of the bands should be dependent on acquisition of the other band i.e. there is no particular complementary relationship between the bands.
- Likewise, the two bands do not appear to be close substitutes to each other. Alternatives to the 2.1GHz band for ZUM include use of other high frequency bands (existing 2.6GHz spectrum holdings and other bands that may become available in the future) to boost LTE network capacity in urban areas. The main alternative to the 700MHz band are the 800MHz and 900MHz bands – ZUM did not succeed in acquiring any of this spectrum in the recent multi-band auction and so the 700MHz band could play a significant role in enabling ZUM to provide extensive network coverage across the whole country. However the 700MHz is complementary to ZUM's existing 2.6GHz holdings rather than to a new acquisition of 2.1GHz spectrum.

In respect of a complete new market entrant, it is likely that such an organisation would have a stronger business case from acquiring both 700MHz and 2.1GHz paired spectrum. This is because the 700MHz band could be used to provide the coverage layer of the network with the 2.1GHz spectrum providing additional capacity. If the Ministry believed there was serious interest from such an organisation, then this would be an argument for combining the award of the 700MHz and 2.1GHz bands. Furthermore, this may necessitate the Ministry setting-aside spectrum in both bands for new entrants as part of the regulations for

a combined auction. In any case, Aetha believes that such interest from new entrants is unlikely as, based on our extensive modelling of the business cases of mobile operators, we do not believe it would be possible to generate a viable business case for a complete new entrant in the Netherlands given mobile penetration exceeds 100% and KPN, T-Mobile and Vodafone all have extensive network operations and distribution channels throughout the country, Tele2 is in the process of rapidly deploying a new mobile network and has an existing MVNO customer base which it can migrate to its network and ZUM may consider deploying a mobile network, but in any case Ziggo has an existing MVNO customer base and Ziggo and UPC are able to use their existing channels to market mobile services to their existing cable customers.

In summary, we have not identified any strong economic linkages that would warrant combining the 2.1GHz paired spectrum and 700MHz band awards.

6.2 Timing of spectrum availability and optimum timing of awards

As discussed in Section 4.1, the main potential acquirers of 2.1GHz spectrum (KPN, T-Mobile, Tele2, Vodafone and potentially ZUM) are all likely to benefit from an award of the 2.1GHz band in line with the Ministry's current plans. The regulations enabling the use of the 2.1GHz paired band for LTE services have been agreed at the European level and an award of the spectrum would provide the mobile operators with the certainty that is needed for making investments in LTE equipment (or possibly 3G equipment in the cases of Tele2 and ZUM) for use in the band.

By contrast, the situation in respect of the 700MHz band is somewhat less certain:

- The timing of availability of the band across Europe for use for mobile service provision is unclear. Some countries would prefer to make the band available as early as 2017, but 2020 appears to be a more realistic date given the extent of negotiations that will need to take place and allowing time for the subsequent implementation of new network configurations/new frequency allocations in individual Member States.
- Agreement needs to be reached on the technical conditions pertaining to the use of the band, in particular the bandplan to be adopted. Work on this is expected to occur during 2013 and early 2014 with a clear European/CEPT position being agreed prior to WRC-15.
- Finally, and most importantly, it is by no means clear whether an agreement on making the 700MHz band available across Europe will be reached. This is a highly political issue and individual countries have very different positions in respect of the importance of the digital terrestrial platform to their economies and societal well-being. At the present time, the process and timescale for making a European Union decision is also unclear, although this may be clarified following the European Commission's publication of a Communication on an Action Plan for Wireless Communications in the next few months.

In view of the huge amount of uncertainty over the creation of and, in the event that agreement is reached, timing of availability of the 700MHz band for mobile services, it is unlikely to be economically beneficial to link a potential future award of the 700MHz band for mobile services to the award for 2.1GHz paired spectrum. There could be many delays in the 700MHz decision-making process and a linkage of the 2.1GHz award with the 700MHz band could result in a significant loss of benefits from delays in the use of the 2.1GHz band for new technologies (such as LTE) and from part of this band potentially being made available to new licensees (e.g. Tele2 and ZUM).

In summary, the linkage of the awards of the 2.1GHz and 700MHz band carries significant downside risk in that delays in the 700MHz process could cause delays in the realisation of the economic benefits from the 2.1GHz band. At the same time, there is no clear upside benefit/case from linking the award of the two bands since, as discussed in Section 6.1, we have not identified any strong linkages between the bands from the perspectives of the most likely users of the spectrum.

7 Conclusions

In this section we present our overall recommendations in respect of the 2.1GHz paired band (Section 7.1), the 2GHz unpaired bands (Section 7.2) and the 700MHz band (Section 7.3), including a discussion of the recommended timing of awards of each band.

7.1 2.1GHz paired band

We recommend that the Ministry proceeds with the development of regulations and design and implementation of the process for the award of this band, independently of other frequency bands.

An auction prior to the expiry of the existing licences would benefit the most likely potential acquirers of the spectrum as follows:

- KPN, T-Mobile and Vodafone would have the certainty required in respect of the future availability of the spectrum to invest in new technologies in the band (in particular LTE). It is important that the existing licensees have sufficient notice of their future spectrum holdings in advance of the expiry of the existing licences since (i) in the event that the operator loses access to some/all of its holdings in the band, it has sufficient time to re-configure its network/deploy additional capacity in other bands and (ii) it reduces the “dead time” at the end of a licence period where no new investments are made (e.g. in deploying LTE technology in the band) due to uncertainty over future access to the band.
- Tele2 (and possibly ZUM) would be able to compete for access to 2.1GHz paired spectrum which could be used to provide additional LTE capacity in the medium to long-term. This would supplement the LTE capacity provided by each organisation’s existing spectrum assets which is likely to be sufficient in the short-term.

7.2 2GHz unpaired bands

We recommend that the Ministry awaits the outcome of work being undertaken by CEPT identifying new technical usage parameters for these bands (the results of which will start to become available from late 2013/early 2014), before making any decisions on the future of these bands - including the regulations governing use of the bands, the award process and the appropriate timing of the award.

In any case, it is looking likely that the future European harmonised technical parameters for these bands will not be set with mobile technologies such as UMTS or LTE in mind, and that the most economically valuable uses of these bands will be for other services (such as Public Protection and Disaster Relief, Programme Making and Special Events, Short Range Devices, for machine to machine applications using DECT technology). **Consequently there is not likely to be an economic case for combining the award of these bands with the award of the 2.1GHz paired spectrum.**

Please note that this does not preclude scope for the unpaired 2GHz bands to be included in the same overall spectrum auction process as the 2.1GHz paired or other mobile frequency bands in view of the efficiencies gained by/cost savings to the Ministry in holding one auction process. However, in this case, it would still be appropriate for the unpaired bands to be considered separately (e.g. a separate parallel auction or in a separate sequential auction) from the spectrum bands that are likely to be used for mobile services in view of the lack of linkage between the bands in respect of the potential users of the spectrum and any overlap in the business cases for use of the bands.

7.3 700MHz band

We recommend that the Ministry monitor EU discussions in relation to this band and depending on how these progress, a timeline and award process for the 700MHz band can be set accordingly.

We do not believe there is a case for linking the award of the 700MHz band with the 2.1GHz band as:

- There is considerable uncertainty over whether the political decision will be made to allocate the 700MHz band for electronic communications services across Europe, the timing that the spectrum would be available across Europe if that decision were to be made and in the short-term there is also uncertainty over the technical usage parameters for the spectrum (including the bandplan to be adopted).
- We have not identified any strong business case linkages between the 700MHz spectrum (in the event it was made available for mobile services) and the 2.1GHz band in respect of the most likely acquirers of the spectrum in both bands (KPN, T-Mobile, Tele2, Vodafone and ZUM).
 - We note that a complete new market entrant could have a business case reliant on both 700MHz spectrum (to provide an LTE coverage layer) and 2.1GHz spectrum (to provide additional LTE network capacity)⁴⁹, but we believe that such a business case of a new entrant is highly unlikely to be viable given mobile market penetration and the number of existing operators in the market and consequently we do not expect such demand to materialise in an award process.

Furthermore, EU discussions in relation to the future of the 700MHz band could take considerable time to be resolved and there could be a significant loss of benefits from the use of the 2.1GHz paired band if its award was delayed whilst the key 700MHz band decisions are made. We also believe that whilst there is some discussion of 2018 being a target date from which the 700MHz band could be allocated to electronic communications services across Europe, 2020 is probably a more realistic earliest possible date for the band to be available on a pan-European basis.

The Ministry will shortly need to make decisions about the future of the digital terrestrial television licence currently awarded to Digitenne. If a firm decision on making the 700MHz band available for mobile broadband services (from a specific date) is made by Europe by the end of 2014, an award process for the new digital terrestrial television licence could be held in 2015 incorporating licence conditions which allow the use of 700MHz spectrum for broadcasting until the specified date and also require the reconfiguration of the DTT network such that the 700MHz spectrum can be released for mobile service use from that time. A separate award for the 700MHz band spectrum (for use for mobile technologies) could be held two years before the date that the spectrum becomes available (e.g. in 2018 in the event that the 700MHz band becomes available for mobile broadband use across Europe from 2020) to allow potential acquirers of the spectrum to develop their infrastructure deployment plans (and GSM/UMTS network switch-off plans) with full knowledge of their low frequency (700MHz, 800MHz and 900MHz) spectrum holdings.

⁴⁹ We also note that if the business case of a new entrant was dependent on having access to both 700MHz and 2.1GHz spectrum, this may necessitate the Ministry setting-aside spectrum in both bands for new entrants as part of the regulations for a combined auction.

In the event that the European decision-making process over the 700MHz band takes some time, it may be appropriate to make short-term extensions to Digitenne's existing licences whilst the long-term future of the 700MHz band becomes clear.

