Vodafone comments on Ofcom's Consultation (June 08) on the Digital Dividend Review (cleared spectrum)

Executive Summary

The digital dividend in the UHF band is the most important spectrum to become available in the UK in at least the last decade, and probably for the next decade to come. It falls in the "sweet spot" in the radio spectrum that is suitable for both capacity and coverage, and is therefore attractive for a wide range of applications. The DDR cleared spectrum award is the most significant that Ofcom has yet undertaken.

Vodafone believes that the most valuable potential use for the upper sub-band of the cleared spectrum is mobile broadband. A recent study by Spectrum Value Partners showed that the European economy would receive a financial boost of at least €95 billion over the next 20 years if around 25% of the UHF broadcasting spectrum were allocated for mobile broadband services, harmonised across Europe.

Ofcom is to be congratulated in its foresight in drawing up an early detailed plan for the release of digital dividend spectrum. However, there is a risk in being at the forefront of developments when others do not always follow, or follow in a slightly different way. For the digital dividend, other European countries have good grounds for not aligning with UK, because the factors that led the UK to its plan do not apply to them. As a consequence of this incompatibility of bandplans the UK could be saddled with a "pioneer's curse" because these proposals will yield, at most, only half the usable spectrum expected to become available elsewhere in Europe. Furthermore, equipment designed for the European market could not be used in the UK. The benefits to the UK economy from this spectrum will therefore be almost completely lost, and UK consumers will not gain access to services available in Europe.

It is therefore essential that Ofcom aligns its proposals for the digital dividend with developments in Europe, in order that UK citizens and consumers will not miss out on the opportunities that will result.

Increasing the availability of spectrum in the upper band suitable for mobile broadband should obviate the need for spectrum caps and in this response Vodafone makes suggestions about how this can be achieved with the minimum disruption.

Given the importance of this award, it is understandable that Ofcom has attempted to accommodate all possible applications. However, this has resulted in a proposed auction design that is so complex as to be effectively unworkable – it will not yield the expected gains, and carries substantial risks. Some of the proposals have also been overtaken by the recent developments in Europe.

We expect that stakeholders, in their responses to this consultation, will give a clear direction on which parts of the digital dividend are most valuable for different applications. We hope that Ofcom will use these responses to the consultation to simplify the structure of the award as it refines its proposals. Vodafone looks forward to contributing to this process.

Vodafone welcomes comments or questions on issues addressed by this submission.
These should be addressed to David Rodman, at david.rodman@vodafone.com

In the sections below we summarise Vodafone's view on what we believe to be the main issues in the consultation document: the configuration of the digital dividend, the design of the auction for the cleared spectrum and the prospective use of spectrum caps.

Vodafone's view on the configuration of the digital dividend

Summary

Vodafone proposes that Ofcom should extend the upper sub-band to channels 61 to 69 (790-862MHz). It is clear that mobile telecommunications will be the most valuable use of the upper sub-band. To make optimal use of this sub-band, it must be aligned with developments in Europe. WRC-07 allocated the frequency range 790-862MHz to the Mobile Service and identified it for IMT. Since WRC-07, the developments in Europe have focused on this sub-band[1]. In particular, the European Commission has issued a Mandate to CEPT to develop channelling arrangements applicable for the sub-band 790-862MHz that are sufficiently precise for the development of EU-wide equipment.

If the upper sub-band in UK is not harmonised with Europe, the value of it for mobile is unlikely to be substantially greater than the recent UK L-Band auction.

To achieve the optimal use of the upper sub-band, Ofcom should:

- Offer channels 61 and 62 as cleared spectrum, and relocate the DVB-T transmissions currently proposed for these channels to the lower sub-band or interleaved channels. In this response, Vodafone proposes a method of substantially reducing the cost and disruption of doing this.
- Offer the spectrum as paired lots of 2 X 5MHz, following the FDD bandplan currently being developed by CEPT in response to the Commission Mandate.
- Use the Technical Licence Conditions (TLCs) also being developed by CEPT.
- Relocate the PMSE currently in channel 69 to the centre gap of this bandplan.
- Release the spectrum nationally in 2012, after the Olympics and Paralympics.

There is no benefit in offering the lower sub-band in lots of 5MHz as well as 8MHz. The auction can be substantially simplified without any significant loss of efficiency if the lower sub-band is offered in frequency specific lots of 8MHz only.

The Economic Case for Mobile Use of the Digital Dividend

In April 2008, the consulting firm Spectrum Value Partners published the report "Getting the most out of the digital dividend – allocating UHF spectrum to maximise the benefits to society"[2],

[1] For example:

France: On 23rd July 2008, the Parliamentary Commission on the digital dividend delivered its report to the Prime Minister. It recommends allocating the entire 790-862MHz sub-band in order to close the digital divide by providing high speed internet access, and encouraging the harmonisation of this sub-band in Europe through the French EU Presidency. See: http://www.dividendenumerique.fr/pdf/Rapport_de_la_CDN_-_23_Juillet_2008_-final.pdf

Sweden: On 19th December 2007, PTS announced that the 790-862MHz band will be made available for new services.

[2] http://www.spectrumstrategy.com/Pages/GB/perspectives/Spectrum-Getting-the-most-out-of-the-digita-dividend-2008.pdf

which represents the first comprehensive economic analysis of the costs and benefits of allocating different quantities of UHF spectrum for mobile broadband and broadcast use throughout Europe. The aim was to determine the optimum balance which would maximise the economic benefit across the EU.

The study showed that allocation of some digital dividend spectrum to mobile would generate additional value of between €63bn and €165bn NPV over 20 years (the results differed from country to country, and between demand scenarios). This is in addition to the estimated €2.5-5 trillion in NPV that mobile generates for the European economy without any UHF spectrum. It also concluded that allocating at least 92 MHz of UHF spectrum to mobile operators would be most likely to maximise the value for the European economy as a whole, and would generate additional value of at least €95bn.

The study modelled a range of plausible mobile demand scenarios, focusing on three specific markets, each representative of three "clusters" of countries; "wealthy terrestrials", where more than 50% of the population receive TV from UHF broadcasting, "wealthy cabsats" where the majority of viewers are on cable or satellite and "less wealthy" countries. Economic benefits from mobile use were calculated, based on the cost savings of using UHF spectrum instead of higher frequency bands already available or expected to become available to mobile operators. For broadcasting, an assessment was made of the additional economic benefit resulting from the extra channels which could be added as the amount of spectrum to broadcasting increased. Having determined the optimum balance for each "cluster" and resulting figures for maximum economic benefit, the results were then scaled to produce an overall figure across the 27 EU countries.

The Shortcomings of Ofcom's Present Proposal for the Upper Sub-Band

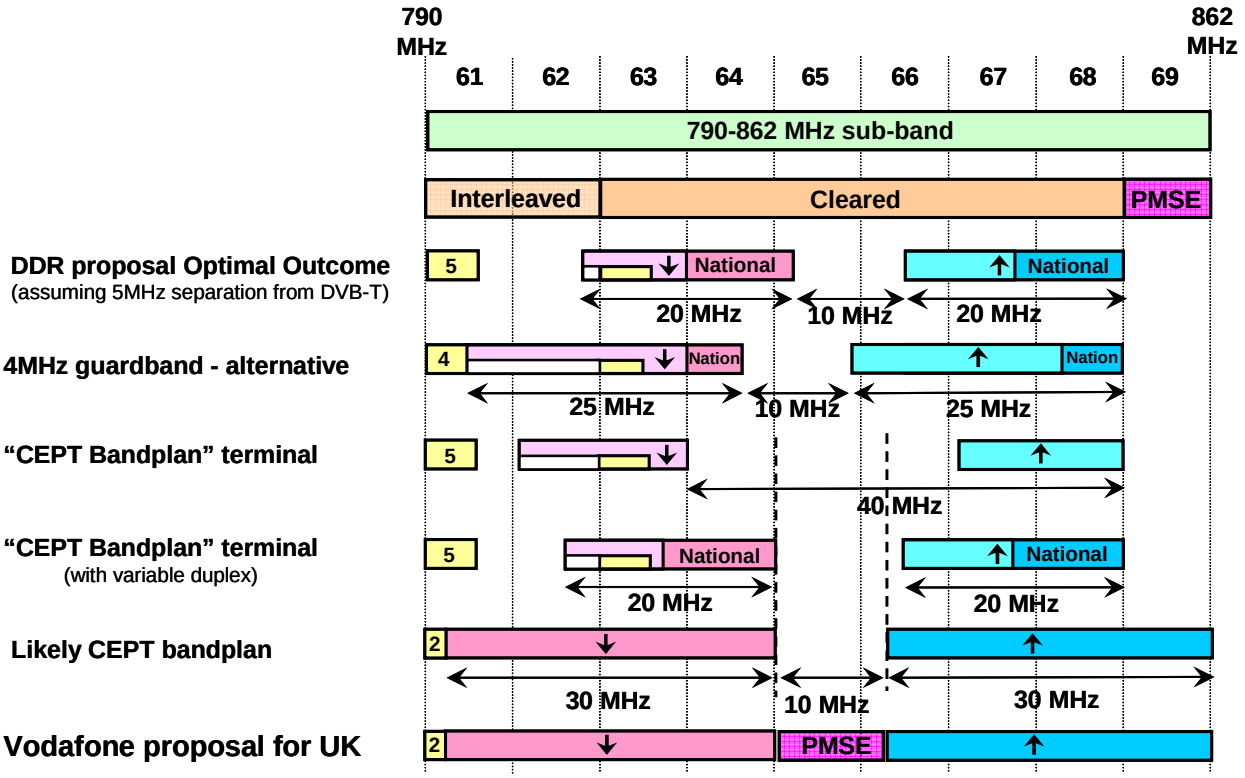
Ofcom's proposals for the digital dividend were developed for the UK alone, before WRC-07 allocated the 790-862MHz band to mobile or the European Commission requested CEPT to develop a mobile bandplan for this frequency range. These two developments will generate a substantial economic benefit through use of this spectrum for mobile broadband. The mobile industry relies on enormous economies of scale to reap these benefits, so the UK can only share in them if the UK plans for the digital dividend are compatible with these developments in Europe. Unfortunately, they are not.

This consultation proposes an upper sub-band of only 48MHz, but less if a guard band is needed. Ofcom concludes that a guardband of 5MHz is needed between new DVB-T and mobile, though this is probably larger than required. The best outcome for mobile within this bandwidth is 2 X 15 MHz of paired spectrum[3]. If a guardband between mobile downlink and broadcasting of 4MHz is sufficient, a different option with 2 X 25MHz (only 2 x 5MHz available nationally) becomes possible. This illustrates the importance of the size of guardband in achieving optimal use of the spectrum.

The most likely outcome of the CEPT studies is a bandplan of 2 X 30MHz, with a centre gap of 10MHz and a guardband to broadcasting of 2MHz. A terminal designed for this bandplan would only be able to support 2 X 15MHz in some parts of the UK, because the downlink would fall within channels 61 or 62 or the guardband to channel 62. A terminal supporting the CEPT uplink and downlink bands, but with variable duplex spacing within these bands, would be able to

[3] This discussion assumes a channel bandwidth of 5MHz, which is the unit for licensing of the 2GHz and 2.6GHz bands, and is standard unit of bandwidth for all leading mobile technologies. It is doubtful that a centre gap of less than 10MHz will be feasible.

support 2 X 10MHz of national spectrum and 2 X 10 MHz of interleaved spectrum. However, we are doubtful that such a terminal would be viable on the European market[4].



It is therefore clearly essential for Ofcom to strive to align its proposals for the upper sub-band with developments in Europe. This would triple the amount of spectrum usable by mobile services. The value of the spectrum would be increase even more, because the utility of the spectrum would not be impaired and there would not be costs associated with UK-specific requirements for terminals.

Relocating Channels 61 and 62

In order to align the upper sub-band with European developments, Ofcom must include channels 61 and 62 as cleared spectrum in the upper sub-band award. This would require the DTV transmissions currently using these channels to be moved.

One of the key reasons why the UK digital dividend is divided into two sub-bands is to avoid needing to move transmissions across the boundary between antenna groups[5], which might result in some households needing new TV reception antennas.

[4] The duplex spacing would be less for UK than for the CEPT bandplan. This would increase the power leaking from the transmitter into the receiver. To avoid the receiver being desensitised, it would be necessary to compensate by improving the performance of the PA or other components. This increases cost and degrades other parameters such as terminal talk time.

[5] The UK is almost unique in having a substantial proportion of domestic TV reception antennas that are not designed to operate over the full 470-862MHz frequency range, in particular, Group C/D spans channels 48-68.

In order to add channels 61 and 62 to the cleared spectrum, the DTV transmissions that currently use these channels must be moved. The potential cost of replacement of domestic reception antennas is significantly greater than the cost of re-engineering the transmission sites. It is therefore desirable to minimise the number of channel changes that involve a change of antenna group. There are two alternatives:

1) The lower cleared sub-band. This is outside of antenna Group C/D. However, Vodafone has developed a technique to avoid changes of antenna group by swapping channels with neighbouring sites. This is described in detail in appendix 2 to this response. We believe that this technique can reduce the cost of clearing channels 61 and 62 to around £100 million. This cost is far less than the economic benefit gained by adding these channels to the spectrum available for mobile services.

2) Interleaved channels. It may be possible to use some of the interleaved channels (as described in the current Ofcom consultation on the Digital Dividend Review Interleaved Awards). However, there is not enough information in that consultation document or otherwise in the public domain to assess the potential of these interleaved channels for this purpose.

Spectrum for PMSE

The centre gap between uplink and downlink of the FDD paired bandplan in the upper sub-band should be allocated to PMSE, as a replacement for the current use in Channel 69. This centre gap is expected to be at least 10MHz wide. This will provide long-term security to PMSE, and more spectrum than currently available in channel 69 (even if a small guardband is needed at the boundary with mobile downlink).

Ofcom is able to provide compensation to PMSE users, either through the Spectrum Efficiency Scheme[6] or by reducing licence fees for existing users in the period leading up to 2012.

The Lower Sub-Band

Vodafone proposes that the lower sub-band should be offered in frequency-specific lots of 8MHz. We believe that the most likely uses of this spectrum are DVB-T and MMS. 8MHz lots will not impair the efficiency of the award even if some of it is acquired for mobile services, because of the constraints resulting from guard bands and channel 38[7].

Complexity of auction design

Vodafone has serious concerns about the huge complexity of the proposed auction design. This complexity can only be justified on the basis of substantial benefits, because it risks an inefficient outcome and increases the costs of participants in the auction. Most of the benefits which Ofcom seeks are illusory, since there is not really substitution between mobile and broadcast in the lower band or the higher band. Mixing different services reduces the amount of spectrum available because of the need for guard bands. In these circumstances, the cost/benefit analysis on the auction design does not stack up.

The complexity of the auction ultimately stems from the proposal that the band plan is defined only through the auction process. The decision to allow for band plans mixing 5MHz and 8MHz

[6] Wireless Telegraphy Act, 2006; Section 1 (5).

[7] See the response to Q29.

lots within both sub-bands results in the need to construct generic lots rather than frequency-specific lots, which in turn creates a split between Principal and Assignment Stages in the auction.

Ofcom attempts to accommodate the valuation differences between lots, and minimise uncertainties, by constructing a very large number (35) of lot types. However, the attempt is unsuccessful, and in any case results in a very large number of possible packages. The large number of possible packages and bids then results in high complexity and slow running-time of the algorithm to determine winners and prices, with a speculated need for parallel processing to compute the outcome in a reasonable time-frame. This would result in a severe lack of transparency for bidders during the course of the auction, and reduce the value of price discovery during the primary bid rounds. It also risks Ofcom having to work to justify the results after the auction. Even the process of entering bids could become highly complicated, particularly for cross-media groups with interests in different spectrum types, who would all be required to bid together under the bidder association rules.

The cascade of complexity could easily be avoided under proposals with a fixed band plan, and by auctioning frequency specific lots, preferably in two separate auctions for the lower and upper sub-bands. If there *were* separate auctions, they might be run at different times, or concurrently. However, even if Ofcom decided to sell all the frequency-specific lots in a single auction, it would still be simpler than the recent L-Band auction.

Spectrum Caps

The obvious premise of Ofcom's advocacy of spectrum caps for spectrum below 1 GHz is that the DDR spectrum in the upper band is substitutable for that in the 900 MHz band in the provision of mobile broadband services. Vodafone supports this view. However, Vodafone is not convinced that spectrum caps are required given Ofcom's existing powers under the Competition, Enterprise and Communications Acts to deal with any competition problems that arise in either upstream or downstream markets. We note however that the imposition of spectrum caps at a level that would bite on only Vodafone and O2 if they were to acquire cleared spectrum would disadvantage those operators to such an extent as to effectively achieve Ofcom's policy objective of achieving a wider distribution of spectrum below 1GHz.

Responses to Questions

Question 1: This executive summary sets out our proposals for the Digital Dividend Cleared Award. Do you agree with these proposals?

No.

These proposals are far too complex, as a result of trying to include every possible option in the auction design. As a consequence, it is very likely that the auction would not produce an efficient outcome for the most valuable uses of the spectrum. Ofcom needs to exercise some judgement on what these most valuable uses will be, and simplify the auction design accordingly. The divergence between Ofcom's proposals for the upper sub-band and emerging plans in Europe mean that terminals developed for the European market probably would not work in UK. Ofcom needs to align its proposal with these plans, otherwise this spectrum will have little value for mobile services.

To achieve an efficient outcome for the auction and realise the full value for the spectrum, Vodafone proposes that Ofcom packages the spectrum as follows:

- Extend the upper sub-band to channels 61 to 69 (790-862MHz).
- Offer channels 61 and 62 as cleared spectrum, and relocate the DVB-T transmissions currently proposed for these channels to the lower sub-band or interleaved channels. In this response, Vodafone proposes a method of substantially reducing the cost of doing this.
- Offer the upper sub-band as paired lots of 2 X 5MHz, following the FDD bandplan currently being developed by CEPT in response to the Commission Mandate.
- For the upper sub-band, use the Technical Licence Conditions (TLCs) also being developed by CEPT.
- Relocate the PMSE currently in channel 69 to the centre gap of this bandplan.
- Release the spectrum nationally in 2012, after the Olympics and Paralympics.
- Offer the lower sub-band as frequency-specific lots of 8MHz.

As a consequence of these proposals, the auction design can be substantially simplified.

It will take some time for Ofcom to address all of the fundamental issues with this licence award. The current proposed timing of summer 2009 for the auction of cleared spectrum is not realistic, nor is it necessary given that the spectrum will not be available for launch of mobile services until towards the end of 2012. The optimal timing for an award of the upper sub-band is the second half of 2010 or later.

Question 2: Do you agree with our proposal to include the interleaved spectrum in channels 61 and 62 in the cleared award?

Vodafone welcomes the efforts of Ofcom to increase alignment of the DDR spectrum awards with developments in Europe. However, the inclusion of interleaved spectrum in channels 61 and 62 is only a small step towards achieving this alignment.

The maps in figure 4.2 of the consultation document give a deceptive impression of the usefulness of these interleaved channels – they show only the DVB-T service areas for these channels, and not the surrounding areas in which other services could not operate. This

spectrum could not be used in most major cities and a substantial proportion of rural UK. Because of guard band requirements, in effect neither channel can be used for other services where one channel is used for DVB-T. These geographic restrictions also apply to the guard bands in channels 63 and above for DVB-T reception in channel 61 or 62.

It is not possible to use effectively such limited and patchy geographic coverage.

Vodafone therefore believes that clearing channels 61 and 62 will provide a substantial benefit though achieving an optimal use of spectrum, which will far outweigh the costs of doing so.

Question 3: Do you agree with our proposal not to allow licence-exempt use of channels 61 and 62 by cognitive devices?

Yes.

There is a fundamental conflict between cognitive access and spectrum liberalisation. Cognitive access aims to allow the use of spectrum resource that is not fully exploited by the primary user. Spectrum liberalisation aims to allow primary spectrum users to change the use of their spectrum so that they can fully exploit the spectrum resource. The two approaches therefore compete for the same spectrum resource, but the primary spectrum user can usually generate more value from exploiting spectrum resources previously unused.

Cognitive devices are at a very early stage of development. The devices developed for the UHF band in USA (and not yet proven to work) rely on an artefact of the US DTV standard that provides an easily detectable signature. They would not detect DVB-T or any other DTV standard, and would therefore prevent future of the technology for DTT broadcasting or any alternative use of the spectrum.

It is therefore correct not to allow licence-exempt use of channels 61 and 62 by cognitive devices. Furthermore, Ofcom should be very cautious about permitting these devices in any part of the UHF spectrum. This could frustrate any future change of use of this spectrum (which might result from future developments in broadcasting) and lead to this spectrum being used very inefficiently in the future.

The negative impact of cognitive devices on the effective use of UHF band spectrum is addressed in more detail in our response to the consultation on DDR interleaved spectrum.

Question 4: Do you have any comments on our assessment of the most likely uses of the cleared spectrum and the amount of spectrum required for these services? Are there any other potential uses that we should consider?

Vodafone believes that the most likely uses of the cleared spectrum are mobile communications for the upper block and DTT for the lower block. Because of the guard bands proposed by Ofcom, the value of MMS would need to be substantially higher in order to outweigh the loss off spectrum on either side of an MMS channel. Some parts of the spectrum (such as channel 38, the centre gap of paired spectrum in the upper block, and “left-over” segments from the allocation process) may have very limited utility for these applications, and the optimal use for this spectrum may therefore be PMSE. However, the award process does not give any special consideration to PMSE (such as defining a category of TLCs).

Question 5: Do you agree that we should proceed with our current timetable, with a view to holding the cleared award in summer 2009?

No.

This timetable is not consistent with Ofcom resolving all the issues that must be addressed before this licence award can take place. We believe that more than one more consultation will be needed before the proposals are mature enough for Ofcom to publish a draft Information Memorandum. There is no need for the licence awards for the upper and lower sub-bands to take place at the same time. The optimal timing for the upper sub-band award is the second half of 2010 or later, though the award of the lower sub-band could take place earlier.

Upper Sub-Band

Before this spectrum award, the following issues must be resolved:

- Re-farming in 900MHz band
- Finalisation of the CEPT FDD bandplan for the 790-862MHz band
- Coordination with neighbouring countries regarding modifications to their DTV channel plans in order to release digital dividend spectrum.
- Identification of alternative spectrum for DTV transmissions currently on channels 61 and 62 (either in the lower cleared band or in interleaved spectrum).

It is desirable for the auction to take place sufficiently before the nationwide availability of spectrum to allow services to be launched as soon as this occurs. Given the likely maturity of the equipment market for this band and the engineering work required, around 18 months lead time would be desirable.

Lower Sub-Band

Before this spectrum award, the following issues must be resolved:

- Coordination with neighbouring countries regarding modifications to their DTV channel plans in order to release digital dividend spectrum.
- Identification of alternative spectrum for DTV transmissions currently on channels 61 and 62.
- Coordination with neighbouring countries regarding use of these channels, if needed.

The spectrum award for the lower sub-band should take place at the same time as the award of interleaved spectrum that is usable to form part of a national multiplex (termed “large lots suitable for aggregation” in the current Ofcom consultation on geographic interleaved awards). A single 8 MHz channel in cleared spectrum has quite similar characteristics to one or more channel in interleaved spectrum, so they are close substitutes. They are also complements, because a number of channels are needed to provide national coverage for a multiplex, and these channels can come from either cleared or interleaved spectrum.

Question 6: Do you have any views on the appropriate notice period for temporary PMSE access to channels 63-68, and/or on whether or not extend temporary access to channels 31-40?

We agree with an extension of the notice period for channels 61-68. If, as Vodafone proposes, Ofcom decides to relocate the broadcasting currently in channels 61 and 62, it will take some time to develop an implementation plan. If Ofcom proceeds with a licence award for only 48MHz in the upper block, then there will be a need for equipment to be developed specifically for the UK market after the auction. In either case, the extension of the notice period would not place any constraints on the future use of the spectrum.

Question 7: What are your views on deferring the start date for rights to use cleared spectrum in London to help meet the need for wireless microphones and other audio links for the London 2012 Olympic Games and Paralympic Games?

Vodafone recognises the need for spectrum to be made available for the Olympic Games and Paralympic Games. We believe that this deferral of the start date for rights also provides an opportunity for Ofcom to reconsider its plans for the upper sub-band to enable an efficient use of this spectrum.

This is discussed in more detail in the introductory section "Vodafone's view on the configuration of the digital dividend".

Question 8: Do you agree with the use of SURs as the approach for defining consistent TLCs for this award?

No.

Vodafone has been supportive of Ofcom's attempts to move towards a more liberalised regime in the UK through the introduction of Spectrum Usage Rights (SUR). We have actively contributed to all five of the previous consultations addressing SUR over the last two years. Despite the best endeavours of Ofcom and stakeholders to date, we believe that there are still many aspects (both technical and regulatory in nature) which remain unresolved. The time and resources which would need to be committed in order to resolve these issues within Ofcom's timescale for the award of DDR spectrum are formidable.

The SURs proposed in this consultation are at a very preliminary stage of development, and are not yet mature enough to be used in an important licence award. As presently proposed, they do NOT define consistent TLCs for interference between different services in the cleared spectrum. Many of the comments made by stakeholders to previous consultations have not yet been addressed in the proposed SUR – see our responses to questions 9, 10 and 15. Given the past rate of progress in developing the concepts of SURs, we anticipate that at least two further consultations will be needed before these SURs would be mature enough for inclusion in a draft Information Memorandum.

Vodafone believes that Ofcom can best foster the optimal use of the upper sub-band by adopting the bandplan for the 790-862MHz frequency range currently being developed in CEPT, in response to the Commission Mandate. Ofcom should then also use the "least restrictive technical conditions" being developed by CEPT under this Mandate for the upper sub-band.

We leave it to stakeholders interested in the lower sub-band to comment on whether SURs should be used to define TLCs in this frequency range.

Question 9: Do you have any comments on the SUR parameters listed in Tables 5.1 to 5.5 and the assumptions used to derive them?

The objectives of spectrum usage rights, as set out in the Ofcom Spectrum Vision[8] are:

- To make spectrum free of technology and usage constraints as far as possible.
- To make it simple and transparent for licence holders to change the use of spectrum.

The SUR parameters proposed in Tables 5.1 to 5.5 do not achieve these objectives. The proposed values were derived from analysis of a single technology with an arbitrary network

[8] Spectrum Framework Review Statement, 28 June 2005, Para. 1.7.

deployment, in some cases using specifications for other frequency ranges. Many of the differences in value between the tables seem to be the result of these different arbitrary assumptions, rather than due to differences in the way that spectrum is used[9].

There should be a close relationship between the SURs and the size of guard bands for different services[10]. These together should define the interference between different services, as well as between networks of the same service. However, the SURs have so far only been developed for the first adjacent channel, which for most of the boundaries between services is a guard band. The reason why a guard band is defined is because the emissions at larger frequency offsets are assumed to be lower. However, this is not reflected in the SURs.

The study commissioned by Ofcom[11] is not adequate for the complexity of defining of SUR for the many potential services in the cleared spectrum. Vodafone has proposed that Ofcom should follow the approach being developed by CEPT for the upper sub-band (see our response to question 8). If Ofcom decides to proceed with SUR for the lower sub-band, then the further studies should address the following points:

1) Given the timescale envisaged for release of the spectrum, LTE is a more appropriate technology than WCDMA to use as a reference for FDD mobile.
2) The parameters used should relate to specifications for the relevant frequency range[12].
3) The simulations should use consistent assumptions for operating frequency (in the current study, some simulations use 586MHz and others use 826MHz).
4) The SURs should take into account the guard bands between services.

See also our response to question 16 (the parameters discussed there have been used in defining the SUR parameters).

Question 10: Do you agree with our proposals for managing interference between new services in the DDR cleared spectrum?

No.

Vodafone believes that the optimal use of the upper sub-band can only be secured if the bandplan for the UK spectrum award is aligned with the bandplan being developed by CEPT for the 790-862MHz frequency range, in response to a Mandate from the European Commission.

Ofcom should award the full 790-862MHz frequency range as cleared spectrum in the upper sub-band licence award, and should follow the FDD bandplan and technical conditions developed by CEPT.

[9] For example, if the values were technology-neutral, one would expect a consistent relationship between the in-band PFD values for TDD and for FDD uplink and downlink, or between the in-band and out-of-band values for these three cases.

[10] The definition of guard bands is effectively recognition by Ofcom that the SUR do not achieve the objectives in the Ofcom Spectrum Vision. If this vision is completely achieved, there would be no need for guard bands to be defined explicitly – the SUR would define the conditions for use of spectrum adjacent to other licence holders such that interference is not caused.

[11] Derivation of Power Flux Density Spectrum Usage Rights; Transfinite Systems Ltd, May 2008

[12] The ITU-R group WP5D has sent a liaison statement to “External Organisations” (i.e. standards organisations involved in the development of specifications for IMT-2000 radio interfaces) requesting information on the characteristics of IMT radio interfaces for the frequency range 698-862MHz. The information supplied in response to this liaison statement could provide some of these parameters.

Observations on guard bands for the upper sub-block

DVB-T – FDD Downlink: The Ofcom studies only considered three specific options for a guard band, of 0MHz, 5MHz and 10MHz. However, the total spectrum available is not an integer multiple of 5MHz, so the optimal value is quite likely also not to be an integer multiple of 5MHz.[13]

DVB-T – FDD Uplink: This is much larger than the guardband for FDD downlink. Therefore, an optimal bandplan for FDD would use "reversed duplex direction", with the uplink below the downlink.

DVB-T – TDD and TDD – TDD: The size of these guard bands leads to inefficient use of spectrum, especially if there is more than operator in the upper sub-band.

TDD and FDD: There appears to be an inconsistency between the proposed guardband between FDD uplink and downlink, and the guardbands between TDD and FDD. TDD uses the same channel for both uplink and downlink; one would therefore expect the guardband between FDD uplink and downlink to be similar to the larger of the two guardbands between TDD and FDD.

Observations on guard bands for the lower sub-block

The size of many of the proposed guard bands leads to a substantial loss of spectrum for most mixes of different services.

It is not feasible to satisfy the guard band and protection conditions and the restrictions relating to channel 38 for more than one viable mobile or for more than two different services within the lower sub-band.

Observations on protection of existing DVB-T

From Table 5.10, it appears that Ofcom is proposing that the protection clause should apply instead of a guard band for the boundary with "existing DVB-T", rather than in addition to one[14]. Ofcom clearly believes that a frequency separation will be needed, because it has defined guard bands between "new DVB-T" and other services. It is unclear why Ofcom has taken a different approach for the boundaries with "existing DVB-T":

- a bidder for mobile would need to acquire an extra lot of 5MHz, even if it believed that a smaller frequency separation provides the optimum trade-off between the costs of spectrum and applying the protection clause.
- a bidder for MMS would need to acquire an extra lot of 8MHz, even though Ofcom believes that a guard band of 5MHz is sufficient.

Ofcom's proposal to not define a guard band between "existing DVB-T" and mobile and MMS also has serious consequences on the efficiency of the auction – see our response to question 25. Vodafone therefore proposes that Ofcom should apply guard bands for "new DVB-T", in addition to the protection clause.

The relationship between the cleared award and the interleaved award

Ofcom proposes a guard band of either 5MHz or 16MHz between DVB-T and other services – though Table 5.10 suggests that this is only intended to apply to "new DVB-T". In the current Ofcom consultation on interleaved spectrum, it proposed to award licences (intended primarily

[13] The best available information is contained in ECC Report 104, which considered a similar scenario between mobile and DVB-T at the 470MHz boundary. It concluded that a guard band of 2MHz is needed.

[14] We comment on this issue here because there is no question in the consultation document in relation to the part of the consultation document containing Table 5.10.

for DVB-T) at lower frequency separations from the boundaries of the cleared spectrum award at channels 31, 40 and 61 (see Table 6.1 of that consultation document). It is not clear from either consultation document what conditions apply for possible interference to services operating in interleaved spectrum from new services in cleared spectrum. We believe that Ofcom intends that there should not be any guard band in the cleared spectrum for interleaved spectrum, and that services in interleaved spectrum should not receive protection from transmissions in cleared spectrum. This needs to be clarified for both awards.

Question 11: Do you agree that the most efficient and effective means of preventing interference to the existing DTT services is by the addition of a protection clause to licences in the cleared spectrum? If not, what alternative approach would you suggest?

We agree with Ofcom that geographic exclusion zones are an inefficient method of protecting existing systems.

It appears from Table 5.10 that Ofcom is proposing that the protection clause should apply instead of a guard band, rather than in addition to one. This approach does not provide any benefits in effective use of spectrum, and it causes serious problems of lot valuation with the current auction design; see our responses to questions 10 and 25 respectively. Vodafone therefore proposes that both the protection clause and a guard band should be applied at the boundaries with existing DVB-T.

We would support Ofcom's suggestion in Para. 5.79, that the protection requirement should be reduced over time. This is consistent with the requirement of EU law that "Equipment shall be so defined and manufactured, having regard to the state of the art, as to ensure that it has a level of immunity to the electromagnetic disturbance to be expected in its intended use which allows it to operate without unacceptable degradation of its intended use"[15].

However, we are not convinced that market incentives on manufacturers will be sufficient to enhance performance of DTT receivers. We therefore suggest that Ofcom, together with BERR, should review the adequacy of current ETSI Harmonised Standards for DTT receivers.

Vodafone's proposal to fully release channels 61 and 62 for mobile use would have the incidental benefit of reducing the potential cost to mobile operators resulting from the protection clause. This is because fewer households will receive DTV on the closest channel to the mobile downlink (around 2.5 million households receive DTV on channel 60), compared with Ofcom's proposals (around 6 million households receive signals on channels 60 and/or 62).

The DTG (Digital TV Group – the industry association for digital TV in the UK) might consider reviewing the RF performance sections of the UK Digital TV Receiver Recommendations to reflect the new use of neighbouring frequencies after digital switchover.

Question 12: Do you agree that the best way to finalise the protection clause approach and to address the practical implementation issues is through direct engagement with interested stakeholders? With which stakeholders should we engage?

We believe that, with good network planning and the adoption of mitigation techniques, the protection clause will not need to be used extensively. However, it is essential that it is clearly

[15] EMC Directive (2004/108/EC), annex I. The R&TTE Directive (1999/5/EC) has a similar provision (Article 3.2) that "radio equipment shall be so constructed that it effectively uses the spectrum ….. so as to avoid harmful interference".

defined, in order that potential bidders for cleared spectrum can evaluate the likely cost of meeting its provisions. For example, the criteria used by Ofcom's field engineers to assess the adequacy of TV reception installations, as described in para. A6.10, need to be clearly defined. Ofcom therefore needs to engage with potential bidders in defining these provisions.

Question 13: What do you believe would be the implications of protecting indoor/set-top antennas? Should a distinction be drawn between set-top antennas and larger antennas designed for external reception of TV signals that are loft-mounted?

Vodafone believes that the probability of interference by mobile services to TV reception is low for the bandplan that we propose for the upper sub-band, provided that the licence holder is careful with network planning and employs appropriate interference mitigation techniques at its basestation sites. However, we recognise that Ofcom cannot rely on all licence holders doing this. Some cases of interference are still likely to occur. It is important that the use of the digital dividend by other services does not create hostility from citizens and consumers. It is therefore important that viewers do not have to bear the cost of curing interference when they have a reception system that is appropriate for the strength of the signal that is received.

In deciding what is an "appropriate reception system", there are a number of factors to consider:

1) For an indoor or loft antenna, the DVB-T signal and potentially interfering signal are likely to be attenuated by similar amounts. Therefore, replacing an indoor or loft antenna by a rooftop antenna does not necessarily cure the interference.

2) The typical directivity of rooftop or loft antennas will reduce the probability of interference occurring relative to indoor antennas.

3) A receiver is typically more susceptible to interference (in terms of C/I requirement) when operating close to its limit of sensitivity.

4) Loft and indoor reception is susceptible to fading from rain on roof tiles and people moving around.

Taking these factors into account, we suggest that viewers who use loft or indoor antennas should receive protection provided that the signal at the input to the receiver exceeds the specified RF sensitivity[16] of the receiver by a reasonable margin (perhaps 6-8dB). A margin (albeit smaller) should also be expected for reception using rooftop antennas outside of fringe coverage areas.

Question 14: **Do you agree with our proposals for managing interference between new and existing users?**

<u>Interference from mobile transmissions</u>

Vodafone recognises the concerns about possible interference from mobile terminals to DTT. This is one reason why we support a paired bandplan with reversed duplex direction for the upper sub-band. With this bandplan, there will be 42MHz separation between mobile terminal transmissions and DTT.

Ofcom has an important role to play in ensuring that transmissions from mobile terminals operating in this band do not cause interference to DTT reception. We envisage that these

[16] The value of RF sensitivity defined in the DTG UK Digital TV Receiver Recommendations (section 2.1) would be appropriate.

mobile terminals will be exempted from individual licensing in accordance with Clause 8 (3) of the Wireless Telegraphy Act 2006. Ofcom would then define the performance of these terminals through an Interface Requirement document, and operators would be required to connect these terminals to their networks in accordance with Article 7 of the R&TTE Directive.

Protection of PMSE services

The technical conditions developed by CEPT for the 790-862MHz band are expected to provide sufficient protection for radio microphones within the centre gap of the FDD bandplan. A small guard band (of a few hundred kHz) would be desirable adjacent to the mobile uplink band, to ensure that basestations are not affected by the out-of-band emissions from microphones. It would be preferable to limit the use of higher power audio links to the centre of this band.

Protection of international radio astronomy services

We recognise that Ofcom is obliged to meet international obligations for protection of radio astronomy, which are defined in ITU Recommendations. However, we believe that these protection criteria are unduly restrictive, and Ofcom should work in CEPT and ITU for them to be reviewed.

The protection criteria are several orders of magnitude below the natural thermal radiation from the ground and other objects. The transmitted power of DTV and MMS transmitters is constant, and the aggregate power from a large number of basestations or terminals (at a separation of several hundred km) will also effectively be constant. These emissions will therefore have the same appearance to a radio astronomy receiver as a minuscule difference in the weather or time of day.

Interference from existing DTT into new services

We agree with Ofcom that there is no need to define guard bands for protection of new services from DTT (but we believe that guard bands may be needed anyway at these boundaries for the protection of DTT). The degree of protection needed will vary with the application, and potential bidders are able to assess the frequency separation needed for the application that they envisage deploying. However, they need information about the DTT networks to make this assessment.

Interference from DTT into new services will obviously be greatest close to the transmitter sites. However, the information in the public domain relates to coverage, which is the furthest distance from these sites. The most important parameter to assess interference from DTT is the vertical radiation pattern of the DTT transmission antennas.

The consultation document does not address possible interference from relay stations (transposers). We understand that the relay stations for the 3 PSB multiplexes will generally only be switched on at the time of analogue switch-over, and there is not yet any complete list in the public domain.

This information is available to NGW/Arqiva. If it is not available to other potential bidders, it could disadvantage them. It is therefore important that this information is available well in advance of the licence award.

Question 15: Do you agree with the proposed propagation models and databases to be used for compliance assessment?

No.

In order to use modelling for compliance assessment, it is obviously essential that the propagation models are valid over the range that they will be applied, and that the terrain and clutter databases contain the data needed to implement the models. This is not the case for the proposals in this consultation:

- The proposed clutter database does not provide all of the information required to implement the propagation models[17].
- The propagation models are not valid over the full range of conditions that would be needed for compliance assessment of Ofcom's current proposed SURs.

These points have been addressed in responses by Vodafone and other stakeholders to previous Ofcom consultations relating to Spectrum Usage Rights. Many of our comments do not appear to have been taken into account in the development of proposals for this licence award, and they still stand[18].

Question 16: Do you have any comments on the transmit masks set out in paras 5.128 to 5.130?

As we stated in our response to Question 8, Vodafone believes that, for the upper sub-band, Ofcom should adopt the TLCs developed by CEPT in response to the Commission Mandate. These are likely to take the form of block-edge masks, which are a type of transmit mask.

There is no justification for the in-band EIRP limit for basestations proposed by Ofcom of +61dBm/5MHz. This value was agreed in CEPT for the 2.6GHz band, even though it is accepted that there was no technical basis for this value[19] [20]. One factor that was considered for the 2.6GHz band was the adjacency of TDD and FDD in the bandplan. This is a factor that

[17] P.1563 requires 3-dimensional data ("representative clutter height"), whereas the proposed clutter database only includes 2-dimensional data. P.1411-4 contains four distinct propagation models, dependent on operating environment. The categories are not consistent with the proposed clutter database. P1411-4 requires building height and other three dimensional data, which is not available from the proposed clutter database. The resolution of the database is also insufficient. These are not criticisms of the database; Ofcom is proposing to use it for a purpose for which it is not intended.

[18] See in particular:

- Vodafone comments on Ofcom's proposals (July 07) for the award of available spectrum: 1452 – 1492 MHz; pages 2-3, response to Q1 and Annex 1 (note that the draft revision to ITU-R Rec. 1456-2 mentioned there has the same content as ITU-R Rec. 1456-3).
- Vodafone comments on Ofcom's Consultation (January 08) on Spectrum Usage Rights (licence verification approaches), response to Q8.

[19] See the report of WG SE to ECC; ECC(08)027,section 3.3: "This figure is the result of compromise reached in SE42 following intense discussion. It is recognised that the maximum in block power for the unrestricted blocks has not been clearly justified in the report [CEPT Report 019]."

[20] See the comments of Vodafone submitted to CEPT on Draft Report 019, page 2: *"It is important to note that the criteria are dependent on assumptions that are specific to the 2.6GHz band. In particular, the in-block radiated power limits (and especially the in-band basestation EIRP limit) are a consequence of the close proximity of uplink and downlink blocks. If block edge masks are applied in the future to further frequency bands, it is essential that the assumptions are reviewed for the band in question."*

Vodafone took into account in its decision to propose a bandplan for FDD only in the upper sub-band.

The study by Spectrum Value Partners shows that the greatest value of the UHF band for mobile services is to provide coverage for mobile broadband. A limit on EIRP will reduce the cell size, which will directly increase the cost of providing coverage in areas of low population density, and will therefore act as a barrier to reducing the digital divide. Ofcom therefore needs to justify any limit on EIRP on the basis of evidence valid for this frequency range. The transmit power limit in Vodafone's GSM licence is equivalent to a significantly higher EIRP density than this proposed limit.

As we point out in our response to question 9, there is a fundamental inconsistency between the currently proposed TLCs and the proposed guard bands between services. At present, the TLCs are only defined for the first adjacent channel, but for most combinations of services this will fall within the guard band. Ofcom needs to define the TLCs for the range of frequency offsets appropriate for all of the defined guardbands between services.

At present, there are no specifications for any mobile technology for operation within the frequency ranges addressed by this consultation. The studies commissioned by Ofcom have therefore used specifications and equipment for other frequency bands, and have apparently assumed that the specifications will be the same. However, this is not a sound assumption, because the interference environment in these other bands will inherently be different. The TLCS developed by CEPT will take account the interference environment in this frequency range, and will therefore provide a sound basis for TLCs for this licence award[21].

Question 17: Do you agree that where the cleared spectrum is used for the operation of a DTT multiplex, we should replicate the ownership restrictions from the Broadcasting Act regime relating to (a) local authorities, (b) political bodies, (c) religious bodies and (d) bodies exerting undue influence but not replicate restrictions relating to (e) broadcasting bodies and (f) advertising agencies?

No comment.

Question 18: Do you agree that we should facilitate interoperability between existing DTT multiplex operators and new operators using cleared spectrum?

No comment.

Question 19: We welcome views on the relative merits of such an approach to information provision; in particular concerning the type of information that may be helpful and any impacts that publication of information might have both on licence holders and the wider spectrum market.

Vodafone has no objection to a public register of spectrum ownership. However, we are not convinced that a condition for provision of information on spectrum use will do much to facilitate secondary trading in the UHF spectrum. There will be relatively few spectrum holders in the cleared spectrum. The information available on Sitefinder and in the public domain (all the expected uses involve services to the general public) or obtainable by spectrum monitoring

[21] Although the CEPT TLCs will only be developed specifically for the upper sub-band, they should form a better starting point for the lower sub-band than any available alternative.

should be sufficient for other players to assess the likely extent of spectrum use. We believe that it is not possible to put more detailed information into the public domain without giving away confidential business plans.

The most likely form of secondary trading in this spectrum is for PMSE use, much of which is very short term. Ofcom proposes to establish a Band Manager for PMSE. It would be reasonable for Ofcom to expect spectrum holders to provide information to this band manager on the spectrum within the UHF band that could be available for PMSE use.

Question 20: Do you agree that the cleared award should include both 8 MHz lots for DVB-T and MMS TLCs and 5 MHz lots for FDD and TDD TLCs across the band?

No.

The proposed auction design with, both 5MHz and 8MHz lots, is far too complex and therefore risks an inefficient outcome. The risk of this inefficiency is far greater than the risk of inefficient spectrum allocation due to lot sizes. Vodafone proposes that the upper sub-band should be offered in lots of 2X5MHz paired channels and the lower sub-band should be offered in 8MHz lots.

Upper sub-band

Vodafone believes that the most valuable use of the upper sub-band will be for mobile services, and the most valuable uses of the lower sub-band are likely to be DVB-T and MMS.

The value of the upper block can only be realised if the spectrum awards are aligned with the bandplan for the 790-862MHz band that is currently being developed by CEPT. It has already been concluded that mixing TDD and FDD on a national basis should be avoided. There is strong interest in Europe from industry in developing FDD equipment for this band, and from operators in deploying this, but we have not seen any comparable interest in TDD.[22]

Vodafone proposes that the centre gap of the FDD bandplan should be used for PMSE, as a replacement for Channel 69. In consequence, it should not form part of this award.

Lower sub-band

As pointed out in our response to question 9, it is not feasible to satisfy the guard band conditions and the restrictions relating to channel 38 for more than one mobile network within the lower sub-band. If a single operator is successful in acquiring spectrum in the lower sub-band, the loss to the pool of spectrum available for DVB-T and MMS would be an integer multiple of 8MHz. Therefore, there is no loss of efficiency in offering this spectrum only in 8MHz lots, regardless of the channel bandwidth that the mobile player intends to use.

Question 21: Do you agree that the cleared award requires a mixture of frequency-specific and frequency-generic lots to be offered in the auction?

No.

We believe that the upper sub-band should be awarded in frequency specific lots of 2 X 5MHz and the lower sub-band should be awarded in frequency specific lots of 8MHz.

[22] The WiMAX Forum is developing an FDD profile for bands below 1GHz, initially intended for the US 700MHz band.

It is only possible to use frequency-generic lots in a spectrum auction when:

- The value of lots is comparable (Ofcom have apparently used a variation of 10% or less as a criterion in previous auctions, as evidenced by warning messages built into auction software when assignment bids are greater than 10% of base prices)
- The value of lots is independent of acquiring other specific lots

For the digital dividend spectrum, these conditions do not hold, because the spectrum is subject to a large number of restrictions:

- For FDD, a lot intended for use as a downlink channel only has any value in conjunction with a compatible channel for use as uplink.
- For the upper block, the downlink channels closest to DVB-T are likely to have lower value because of the protection clause.
- Some players might value lots adjacent to guard bands more highly, if they consider that it could be possible to negotiate with the neighbouring spectrum holder to reduce the guard band.
- For DVB-T, it is likely that only certain channels can be used at particular transmission sites due to planning criteria for DVB-T networks.
- For DVB-T there could be differences between channels in the lower sub-band due to antenna groups.

Frequency generic lots are only needed when the partitioning of the spectrum is defined through the auction process. Vodafone's proposal for the lot types avoids this need. Our proposal would allow Ofcom to auction 14 frequency-specific lots (8 in the lower sub-band and 6 in the upper sub-band), and to do so either in separate auctions for the lower and upper sub-bands or in a single combined auction. See also our answers to questions 28 and 29.

Question 22: Do you agree with the proposed outline definition of lots suitable for MMS, DVB-T, TDD and FDD applications?

Vodafone has proposed that channels 61 and 62 should be offered as cleared spectrum. It will therefore be necessary to find alternatives to these channels, either within the lower sub-band or in interleaved spectrum. Our initial proposal would be to use channels 39 and 40 for this purpose, but this needs to be confirmed using a broadcast frequency planning tool.

- In para. 7.67, Ofcom recognises the importance of alignment with the harmonised European bandplan. However, the analysis in the following paragraphs presents a very rosy view of the extent of alignment that is achievable under the present proposals: Ofcom proposes to release channels 61 and 62 as interleaved spectrum. Therefore, any paired channels with the lower channel falling in this range will be of very little value.
- The value of paired spectrum will vary greatly with duplex separation, particularly depending on whether it is the same as the European bandplan.

As we have stated in responses to other questions, we believe that the upper sub-band should be awarded in paired lots of 2X5MHz and the lower sub-band in lots of 8MHz. Much of the detail of the definition of lot categories would then not be needed. This is discussed in more detail in the introductory section on "Vodafone's view on the configuration of the digital dividend".

A further lot type is necessary for PMSE. See our response to Question 24.

Question 23: Should the flexibility to bid for lots defined on both fixed and variable-frequency rasters be preserved in the auction? If not, which are preferred?

No. A fixed raster is preferred.

As discussed in answers to earlier questions, we believe that Ofcom should adopt the bandplan being developed by CEPT for the upper sub-band. This will have a fixed raster.

It is only feasible to deploy one mobile network in the lower sub-band, and there is no loss of efficiency in awarding the spectrum only in 8MHz lots. For a single mobile or MMS network, there is no need to consider the raster in the award process.

Question 24: Do you agree with the proposed basis for awarding Channel 38 as a distinct lot in the auction?

Yes, in general.

The restrictions on the use of Channel 38 are particularly onerous, and are so great that the most valuable use of this spectrum could be PMSE (especially radio microphones for use indoors). This is unlikely to need any guard band relative to the services in channels 37 and 39. However, there is no suitable set of TLCs defined in Tables 5.1 to 5.5. The current auction design could preclude the use of Channel 38 for PMSE if the lot categories above and below are different, because of the requirements for guard bands defined in Table 5.10.

The restrictions on channel 38 are geographic, and it would be possible to operate high power services in the north of the UK. To make this possible, it would be necessary to meet the guard band conditions in the auction. This would require a separate lot category for each class of service that might be operated in this channel, including a lot type and a sixth set of TLCs for PMSE.

The set of TLCs for PMSE could also be used for the centre gap of the FDD bandplan in the upper sub-band.

Question 25: Do you agree with the proposed structure of frequency rules for allocating different licence types in the auction? Are there any amendments that would improve the efficiency of spectrum allocation via an auction?

Vodafone proposes that the upper sub-band should be awarded in frequency specific lots of 2 X 5MHz for the frequency range 790-862MHz, and the lower sub-band should be awarded in frequency specific lots of 8MHz. This will improve the efficiency of the award process, and lead to the most efficient spectrum allocation. We expect the responses to this consultation to confirm that these proposals provide enough flexibility to meet the needs of the market.

The present lot structure is far to complex to be confident of an efficient outcome. There are far too many possible permutations to be able to analyse them all in advance of the auction, and they are too complex to analyse properly once the auction is underway.

Ofcom recognises (para. 7.100) that it is important that features of the CEPT bandplan should be reflected. However, Ofcom's proposals do not appear to recognise the aspects of the bandplan that must be aligned in order to achieve the benefits of harmonisation. In particular, it is imperative that terminals designed for the European market can be used in UK:

- The centre gap must have the same frequency range; for FDD, this is determined by a hardware component in the terminal (the duplex filter) that cannot be tuned.

- The separation between uplink and downlink channels cannot be reduced. This would increase leakage of out-of-band emissions from the transmit chain of the terminal into its receiver, which would desensitise the terminal[23].

This is discussed in more detail in the introductory section on "Vodafone's view on the configuration of the digital dividend".

Guard bands

Ofcom proposes that the protection clause should apply instead of a guard band, rather than in addition to one. Ofcom has attempted to address this through the definition of lot classes and winner determination rules. This approach is different to Ofcom' approach for boundaries between new services (including new DVB-T), in which the guard bands do not form part of the lots but are assigned separately by the auction software algorithm. This difference in approach would result in significant variations in valuations of lots, and a considerable increase in complexity for bidders in the auction. It would also complicate the definition of eligibility points - it is essential that equivalent sets of lots in terms of usable spectrum do not have different numbers of points depending on whether or not extra spectrum is needed to separate the transmissions from existing DVB-T.

Question 26: Do you agree with our proposal to proceed on the basis of UK-wide lots?

Yes.

For mobile services, regional lots would lead to substantial inefficiencies because the spectrum could not be used effectively close to the boundaries (the areas affected would be quite wide at this frequency). For broadcasting, regional lots are available in interleaved spectrum.

Question 27: Do you favour including the available cleared spectrum in (a) Guernsey and (b) Jersey in the geographic coverage of the licences to be awarded? If not, what approach do you favour instead?

Ofcom needs to clarify whether spectrum awarded in these Crown Dependencies would confer the same rights to operate a mobile network as in UK.

Question 28: Do you agree that the combinatorial clock auction is the most suitable auction design for the cleared DDR award?

Not in the complex form currently proposed. While a simplified form of CCA could be suitable, that simplified case would also be served by the more familiar SMRA with package bidding.

Vodafone has very significant concerns about the proposal that a band plan is only defined through the auction process. This proposal has a lot of knock-on consequences, and these consequences create serious concerns about the whole auction design:

[23] Some of these constraints could, in principle, be reduced if the mobile network used half duplex FDD. The GSM Association has commissioned an independent study from RTT Systems to examine the potential of half duplex FDD for the UHF band. This study concluded that the technique is not sufficiently mature to be relied upon for deployment in the UHF band in the timescales envisaged by Ofcom for the cleared spectrum award, or the proposals for release of spectrum in other European countries.

1) The decision to allow for band plans mixing 5MHz and 8MHz lots within any given sub-band results in the need to construct generic lots, a need which could easily be avoided under proposals with a fixed band plan.

2) The use of generic lots in turn creates a split between Principal and Assignment Stages in the auction, with a potential for uncertainty or conservatism in the Principal Stage.

3) There is an attempt to accommodate the valuation differences between lots, and minimise uncertainties, by constructing a very large number of lot types. However, the attempt is unsuccessful, and in any case such a large number of types results in a very large number of possible packages.

4) This then results in high complexity and slow running-time of the algorithm to determine winners and prices. This high complexity creates a severe lack of transparency for bidders during the course of the auction, and significantly reduces the value of price discovery during the primary bid rounds.

5) The high complexity also risks Ofcom having to justify the results after the auction.

These points are explained in further detail in appendix 1 of this response:

Question 29: What potential simplifications, if any, could be made to the proposed lot structure for DVB-T, MMS, TDD and FDD lot categories which would still reflect the most important differences in value between lots?

Vodafone proposes that:

- The upper sub-band should be offered in frequency specific lots of 2 X 5MHz, following the FDD bandplan currently being developed by CEPT for the 790-862MHz frequency range.
- The centre gap of this bandplan should be made available for PMSE, to replace channel 69.
- The lower sub-band should be offered in frequency specific lots of 8MHz.

We believe that this will allow an efficient outcome for the auction for the full spread of reasonable market demands, once the constraints due to guard bands and channel 38 are taken into account. Vodafone does not expect there to be significant interest in the lower sub-band for mobile services. However, even if there is, there is no loss in efficiency from awarding this spectrum only in lots of 8MHz[24].

We believe that generic lots are not appropriate for this auction, because the differences in value between different parts of the spectrum on offer are too great (to at least some potential bidders).

These points are discussed in more detail in the introductory section “Vodafone’s view on the configuration of the digital dividend” and responses to other questions.

[24] It is only feasible to deploy one credible mobile network within the lower sub-band while meeting the constraints of channel 38 and the guard bands. If part of this spectrum was awarded for mobile use, the spectrum removed from the “pool” available for DVB-T and MMS would always be a multiple of 8MHz, regardless of the channel width of the mobile system that might be deployed.

Question 30: Do you have any comments on our proposals for the Application and Qualification Stages of the combinatorial clock auction for the cleared DDR award, including our proposals for initial deposits?

Vodafone would like to make two comments. The first is the same as a point that we have made in connection with the 2.6 GHz auction consultation; the second is specific to the DDR auction.

The relevance of 'confidential information' to bidder qualification

The proposals include a provision under which a potential applicant could be disqualified if it has obtained confidential information relating to another applicant. 'Confidential information" is defined as "*any information which is not in the public domain and which, if it were made public, or disclosed to another applicant (or potential applicant) or bidder or a member of their prospective bidder groups, would be likely to affect decisions that such other applicant (or potential applicant) or bidder may make in relation to the award process;*".

This definition of confidential information seems very broad, especially when the potential range of applicants is so wide. Vodafone thinks Ofcom should take a fresh look at this definition to see whether it could be tightened up without undermining its core intent. At the least, the provision should include a start date (i.e. clarifying that any exchange of information prior to that date would not be caught). It is in no-one's interest for disputes about the possible exchange of confidential information, however ill-justified, to risk excluding genuinely independent bidders from the auction.

The requirement for associated bidders to bid together

Clause 8.79 of the consultation states that Ofcom "will notify each applicant of the names and associates of all other applicants and set a date by which applicants must notify us as to whether any members of their bidder group are also associates of another applicant".

Clause 8.80 states that "An applicant may not qualify if a member of its bidder group is also a member of another bidder group as indicated above".

Read together these would imply that applicants who are associated in any way would need to form part of a single bidder group.

As noted in Vodafone's response to Question 28, this could have a significant impact on cross-media groups or associations with an interest in broadcast television, fixed broadband (and hence potentially fixed wireless broadband), mobile and/or MMS. It might result in different companies within those groups with quite different commercial motives being forced to form a common bid team and then ask for hybrid packages involving multiple types of lot. As the valuations will be composites based on the different parties' business models, the bid team might be required to calculate and express their composite valuation for a huge number of possible bid packages.

Holding the auctions for the lower sub-band and upper sub-band separately would significantly reduce this problem, as the different companies within a cross-media group could then form separate bid teams targeted at the different auctions (e.g. separate out their broadcast and telecommunication arms) and bid for a much smaller number of packages in each auction.

Question 31: Do you consider that it is important to distinguish relative weightings in advance between the eligibility points of the different 1 MHz blocks available in this award? If so should this be restricted to channels 36, 38, 61 and 62 and what do you consider these relative weightings should be?

Under Ofcom's proposal, it would be important to assign different eligibilities where there are known impairments (e.g. to channel 38 and to necessary guard bands), although this would be a difficult task. Ideally, the eligibility would be roughly proportional to each lot's value, and of course this is not known until the auction has been run.

Note that under Vodafone's proposal, this question would not necessarily arise. If there were two auctions held separately for the upper and lower sub-bands – each say under SMRA with package bidding, pay as bid, and with limited numbers of specific lots - then an activity rule based on eligibility points might not be necessary. The activity rule might be very simple (e.g. you can't bid for a package if you already bid for a strict subset when the price was lower). Or use of advanced deposit requirements could help ensure that bidders' demands trend downwards rather than suddenly surging upwards towards the end of the auction.

Question 32: Do you have any views on whether an ex ante eligibility points activity rule or a revealed preference activity rule should be used in this award?

See Vodafone's answer to question 31 above. A revealed preference rule might be more useful under Ofcom's proposals than a fixed eligibility rule, though it would make the auction design more complex still, again in contrast with Vodafone's proposal.

Question 33: Do you have any views on whether there should be restrictions on bidders' ability to bid on multiple technical licence types within single package bids or between different rounds of the auction and whether bidder association rules should potentially be adjusted to cater for any such restrictions being imposed?

See Vodafone's answers to questions 28 and 30 above. Placing restrictions on the number of licence types within a given package would definitely reduce the complexity of the auction software (and price calculation tool). It would also prevent bidders from covertly switching bids between licence types to maintain eligibility.

However, if Ofcom wished to exploit this complexity reduction, and still hold a single auction for all cleared spectrum together, there would need to be a change to the bidder association rules, to allow different parts of a cross-media group to bid separately for broadcast spectrum, mobile spectrum etc. As this would give rise to great problems of preventing collusion, it is a strong argument for holding the auctions of different licence types separately.

Again, Vodafone's proposal would mitigate the problem, as there would only need to be a single licence type available in each of two auctions, or at most two licence types in a single auction.

Question 34: Do you have any further comments on any aspect of our proposals for the Principal Stage of the combinatorial clock auction for the cleared DDR award?

Vodafone would like to make two comments, which are essentially the same as points that we have made in connection with the 2.6 GHz auction consultation. These comments only apply in the case that Ofcom uses a combinatorial clock auction.

<u>Auction information policy</u>

In the current consultation (8.136), Ofcom proposes to publish only the aggregate demand for each category of lot. This is a change from an earlier position, set out in the December 2007 2.6 GHz consultation (which Ofcom terms the 'Auction Rules Consultation'), under which it would

publish at the end of each Primary Round the aggregate demand for paired and unpaired lots, the number of remaining bidders and the packages bid for.

We are unclear why Ofcom have recently changed position with regard to information policy in auctions, and believe it would be detrimental in its effect, for at least two reasons:

(1) If a bidder has a standalone valuation of spectrum (i.e. one which would apply whatever the distribution of spectrum at the end of auction), Ofcom's position would act to prevent that bidder from being able to compare its own valuation with a *range* of other bidders' emerging valuations. This increases the risk of the bidder overpaying for any spectrum won – the "winner's curse" – which would undermine the auction objective of arriving at an efficient allocation of spectrum in line with bidders' true valuations.

(2) If a bidder's valuation is contingent at least in part on the number of other successful bidders, Ofcom's position again risks leading to an inefficient outcome by preventing the bidder from seeing how many other bidders remain in the auction at any given time. In this situation, it is quite likely that a bidder could overpay in winning spectrum, or drop out of the auction too early.

Calculation of base prices

In the current DDR consultation (8.158) Ofcom has described the second price rule as being the minimum price needed to ensure that:

"there is no alternative combination of bidders prepared to pay more than any winner or group of winners".

However, in the case of the 2.6 GHz auction, we noticed a material inconsistency between this verbal description of the second price rule and the criteria for the base prices ("reduced winning principal stage bids") as given in the draft Award Regulations:

"*the combination of the reduced winning principal stage bids submitted by the winning bidders would have been the valid combination of principal stage bids or one of the valid combinations of principal stage bids (as the case may be) having* ***the highest total value of amounts bid.***" [emphasis added]

The key issue is whether the base price calculation is only affected by rival bid combinations involving a ***losing*** bidder (ie the prices are sufficient to ensure that no losing bidder or bidder combination can object). Or can it also be affected by rival bid combinations made purely by the ***winning*** bidders (i.e. the prices must be high enough to ensure that no winning bidders can object either)?

The issue is material, as it concerns the actual amount that a winning bidder may pay for a licence. Of the two formulations, Vodafone prefers the former (ie the version where the prices are sufficient only to ensure that no losing bidder can object), not least because this is the way that we have understood Ofcom to have been describing its intention throughout recent auctions involving this second price rule.

Above all, however, it is essential that Ofcom should arrive at one definitive formulation of this central provision and ensure that all potential bidders are fully informed of the impact of the chosen formulation in practice.

Question 35: Do you have any comments on any aspect of our proposals for the Assignment Stage or the Grant Stage of the combinatorial clock auction for the cleared DDR award?

Vodafone would like to make one comment, which is essentially the same as a point that we have made in connection with the 2.6 GHz auction consultation. This comment only applies in the case that Ofcom uses a combinatorial clock auction.

Disclosure of all bids received after the auction

In the current DDR consultation (8.158) Ofcom states that:

"We would also expect to make publicly available all information relating to the bids of each bidder in each of the primary bid rounds, all of the bids submitted by each bidder in the supplementary bids round and assignment stage bids from winning bidders, together with the monetary value of all of these bids."

Vodafone finds this provision troubling, given that the UK auction is relatively early in the anticipated round of auctions for largely the same spectrum bands across Europe. Although the disclosure of all bids after an auction finishes could have no impact on an isolated auction, it could yield information of potentially great significance to parties intending to bid in subsequent similar auctions.

The key area of difficulty lies in the supplementary bids round, in which a bidder might choose to enter supplementary bids for a very wide range of spectrum packages. Most of these will end up having no bearing on the result of the UK auction, but collectively they could reveal information about that bidder's general valuation approach to competing bidders in later auctions. This risk could serve to constrain the bidding behaviour of some UK auction participants, but not others (if they expect to have little or no interest in subsequent auctions), leading to an unfair distortion in the UK auction process and possibly the outcome.

Vodafone entirely understands the desire to publish all relevant information after the auction finishes, but we would urge Ofcom to reconsider whether this really necessitates the disclosure of the precise level of all bids in the supplementary round. We think it should be possible to publish sufficient information about bids in this round so as to demonstrate that the auction outcome was in line with the regulations, without publishing the precise amount of all bids.

Question 36: Do you agree with our approach to assessing whether the award of cleared spectrum fully promotes competition and efficiency?

No.

See answer to question 42.

Question 37: Do you have particular concerns about possibilities for award outcomes to fail to fully promote competition in downstream markets or to result in inefficient use of spectrum? If so, please explain what these are and provide supporting evidence.

Vodafone has a fundamental concern that the misalignment of the UK's bandplan with that adopted elsewhere in Europe will effectively prevent the spectrum being used efficiently for mobile services.

Unless the cleared spectrum is all awarded for DVB-T, a significant proportion of the spectrum will be required for guard bands. The consultation does not make adequate proposals to make

efficient use of this spectrum, subject to the constraints of protecting the services in the neighbouring channels. It is likely that PMSE could make effective use of these guard bands, because it is low power (especially radio microphones), has a low transmitter density, and can be coordinated. We suggest that Ofcom takes the following steps to ensure that the guard bands and unused spectrum can be used effectively:

1) Vodafone has proposed that the upper sub-band should be awarded as lots of 2X5MHz paired channels with a centre gap of around 10MHz. This centre gap should be included in the spectrum managed by the proposed PMSE Band Manager, as a replacement for channel 69.

2) Vodafone has proposed that guard bands should also be defined at the boundaries of the lower sub-band with existing DTV. Depending on the outcome of the auction, there may also be a residue of spectrum retained by Ofcom. These could also be included in the spectrum managed by the PMSE Band Manager.

3) Ofcom should facilitate the use by PMSE of the guard bands between users. In particular, should encourage the proposed PMSE Band Manager to undertake this task.

Question 38: Do you agree with our view that we should introduce a general safeguard cap aimed at promoting diversity of spectrum holdings? Do you have views concerning the level of such a cap?

Vodafone's proposal is to auction the upper and lower bands in different sized lots. We do not believe that spectrum will be substitutable between the upper and lower bands. This will mean that a spectrum cap covering the whole of the band is unnecessary and Ofcom should consider whether spectrum caps are warranted in either of the sub-bands; see our response to question 43 below.

Question 39: Do you agree with our proposals to include an information provision licence condition to help facilitate efficient secondary trading?

No. See our response to Q19.

Question 40: Do you agree with our view that we should not apply any other general remedies in the cleared award?

Yes.

However, Vodafone believes that the evidence from the '2G world' supports our view that operators with access to spectrum below 1 GHz will compete to supply commercially negotiated access agreements.

Question 41: Do you agree with our identification of the three areas requiring further attention?

No. See our response to question 42.

Question 42: Do you agree with our assessment that the limitations on the amount of cleared spectrum available for mobile broadband applications, and the particular

advantages of sub 1GHz spectrum, could result in an outcome where there are limits on the level of competition possible in the provision of these services?

No.

Ofcom has made an assertion and not an assessment that the finite supply of sub-1GHz spectrum could limit competition for 'mobile broadband applications'. It adduces no evidence in support of its position.

Ofcom admits that its 'assessment' is necessarily speculative but this should not excuse it from defining its terms, elucidating the steps in its logic or providing some evidence. For example:

- Ofcom appears to identify a new market: 'mobile broadband' and yet there is no attempt to either define or delimit such a market or attempt to relate it to a wider market for mobile services.
- Ofcom points to the *"advantages of low frequency spectrum…for these services"*. However, there is no attempt to assess the magnitude of these benefits; either in 2013 when the cleared spectrum will be available nationwide or later when the spectrum will presumably be deployed. Such an assessment would need to consider the award of unpaired spectrum in the 2.6GHz band and subsequent possible deployment of WiMAX on the state of competition in the market for mobile broadband applications (i.e., the number of potential competitors) and the further build-out of 3G networks at 2.1GHz by the five existing mobile network operators (i.e., the extent to which existing operators will already have extensive mobile broadband networks and therefore whether sub 1GHz spectrum will provide any coverage economies).
- The absence of analysis of the relative advantages of low frequency spectrum is matched by a similar failure to identify the regulatory risks associated with applying an ex ante remedy to an input.
- Ofcom appears to take it as self-evident that unless the available spectrum supports the maximum number of players possible then there will be *"limits on the level on competition".* This, of course, ignores the possibility and impact of service-based competition. Moreover, this is an empirical matter that is almost impossible to predict and therefore is best left to ex post interventions in the relevant downstream market (see our answer to question 43).

Vodafone believes that Ofcom needs to do more than simply speculate about the future state of competition in a nascent market and assert that there is likely to be something worth worrying about before it proposes such a potentially draconian remedy (see our answer to question 43).

Question 43: Do you think that a soft spectrum cap on either (a) the cleared spectrum suitable for mobile broadband applications alone, or (b) the holding of any sub 1GHz spectrum suitable for mobile broadband applications, which would trigger action if a significant competition concern emerges in relation to the market structure in the future mobile broadband market, could be an appropriate approach to these concerns?

It should be clear from our answer to question 42 that Vodafone does not believe that Ofcom has made a robust case that there is sufficient likelihood of the emergence of a 'competition problem' worthy of such an intrusive remedy as a soft spectrum cap. If Ofcom considers that the availability of sub-1GHz spectrum could give rise to competition concerns then its first priority should be to increase supply by clearing more spectrum in the upper band.

Vodafone has a number of specific comments on soft spectrum caps:

- Ofcom appears to favour a soft spectrum cap on spectrum below 1 GHz. Vodafone submits that such a cap should not be implemented into the licensing regime for the cleared spectrum until there is a final decision on the re-farming of 900 MHz spectrum (i.e., after any litigation). It cannot be the case, if Ofcom desires an efficient auction, that operators are expected to bid for spectrum below 1GHz without knowing whether they are likely to be subject to a spectrum cap, with potentially draconian consequences if breached.
- The consultation document contains no suggestion of the level at which the spectrum cap may be set. However, Vodafone suggests that, providing the cap does not bite on all operators (i.e., those with spectrum below 1GHz at the present time and those awarded cleared spectrum in the auction), then the imposition of a spectrum cap (and the consequent potential sanction) is likely to mean that those caught by the cap are unlikely to prevail in the auction. In other words, the risk associated with being subject to the cap is likely to impact significantly affected participants' valuations of the spectrum to such an extent that they will be outbid by others who will not face a cap.
- The logic of Ofcom's promotion of spectrum caps is that spectrum below 1GHz is fungible i.e., that the DDR spectrum **is** a substitute for 900MHz spectrum as an input to the supply of mobile broadband services. In Ofcom's September 2007 consultation on the application of spectrum liberalisation and trading to the mobile sector it concluded that *"…this is not likely to be the case, and that within the timescale that is relevant to this decision the DDR spectrum is unlikely to be a substitute for the 900MHz band. While in pure propagation terms the respective frequencies are similar, there are uncertainties over many aspects of the potential use of the DDR band for mobile services. These include the extent to which any mobile use would be on a harmonised basis across Europe, and (related to this) the extent to which equipment might be available to make use of the band, the standards that this equipment would use, the costs of that equipment and the timing of its availability. There is also a difference in the timing of the availability of the two bands, as the DDR spectrum will not be available for nationwide mobile use until the end of 2012, at the earliest."* Vodafone supports the proposition that 900MHz and DDR spectrum (and indeed 1800MHz spectrum) will be substitutes in the provision of mobile broadband services from 2012[25] and indeed Vodafone's proposals for the release of more DDR spectrum in the upper band will significantly enhance the substitutability of the DDR spectrum. Vodafone also notes Ofcom's view that *"if the digital dividend spectrum that could be allocated to mobile were a good substitute for 2G spectrum at 900 MHz, then this would reduce the need for achieving a wider distribution of the 900 MHz spectrum, provided that sufficient spectrum were available for non-900 MHz operators to address the types of competition concerns outlined above".* (paragraph 6.24)
- If Vodafone is correct that a) a spectrum cap that bites on the incumbent 900 MHz operators will, in effect, prevent them from being successful in the auction of cleared spectrum and b) it is Ofcom's belief that (as it is Vodafone's) that 900 MHz spectrum and the cleared DDR spectrum will be effective substitutes and c) Ofcom should release channels 61-62 and 69 to maximise the utility of the DDR spectrum for mobile broadband then the imposition of the spectrum cap will ensure that *"sufficient spectrum were available for non-900MHz operators"* since each of the non-900MHz operators could acquire 2 x

[25] See our response to Ofcom's September 2007 consultation on the application on the application of spectrum liberalisation and trading to the mobile sector.

10MHz of spectrum between 790-862 MHz [we note that in the re-farming consultation Ofcom's analysis indicated that *"a 3G operator could obtain most of the cost and quality advantages of 900 MHz with access to just one 2x5MHz block of 900 MHz spectrum. It is likely to need further spectrum for capacity reasons but this could be at higher frequencies"* (paragraph 11.15)]. Put simply, the imposition of spectrum caps at a level that will constrain the 900 MHz operators alone will achieve Ofcom's policy objective of allowing more than two operators the option of rolling out mobile broadband services at spectrum at or below 900 MHz.

- Ofcom needs to explain why its ex post powers are inadequate to deal with "competition concerns" arising from the award of cleared DDR spectrum and why it is suddenly persuaded about the efficacy of spectrum caps. Ofcom wrestled with similar issues in 2004 when it considered how to ensure effective competition following the introduction of spectrum trading: *"Companies could limit competition in downstream markets by purchasing spectrum which forms an essential/necessary input to the downstream market and then preventing competitors from accessing it"* (paragraph 2.8).[26] At that time Ofcom believed *that "the Competition Act will be effective at dealing with any anti-competitive behaviour that may arise in spectrum markets or related downstream markets to which spectrum is an input"* (paragraph 1.4) and that *"…in relation to markets for goods or services to which spectrum is an input, Ofcom could refer the market to the Competition Commission for investigation if it had reasonable grounds for suspecting that any feature(s) of that market distorts competition in the supply of those goods or services"* (paragraph 1.5) and furthermore that *"Ofcom has powers to impose obligations on undertakings found to have Significant Market Power under the Communications Act"* (paragraph 1.6). Ofcom also explicitly rejected spectrum caps because they could: *"inhibit market growth"*, *"prove controversial to apply"*, *"deter trading"* and moreover they are *"unlikely to be effective in preventing anti-competitive behaviour. In particular, spectrum caps fail to take account of the level of market power and the fact that, in many cases, there may be alternative ways of delivering the downstream service other than by using spectrum"* (paragraphs 3.46 and 3.48).
- Ofcom should give consideration as to whether spectrum caps are necessary. If sub-1GHz spectrum does confer an advantage on its owners in the rollout of mobile broadband services then the existing holders of 900 MHz will expect to enjoy such advantages in the future anyway. If this is the case then the incremental value of an additional quantity of sub-1GHz spectrum to existing 900 MHz operators should be lower than that for the non 900 MHz operators. In other words, if Ofcom is correct then an efficient auction, by itself, should ensure a wider distribution of sub-1GHz spectrum. If, rather, Ofcom is suggesting that the lure of monopoly rents will persuade the 900 MHz operators to ensure success in the auction then it will again need to explain why its extensive ex post powers are insufficient to deal with the eventuality.
- Ofcom's perception of the distinct characteristics of spectrum below 1GHz is based in part on technical factors that might change during the lifetime of the licence[27]. Therefore, any soft spectrum cap should apply for all mobile spectrum, regardless of frequency.

[26] See Statement: Ensuring effective competition following the introduction of spectrum trading. September 2004

[27] For example, the deployment of relays could substantially reduce the effect of differences in radio propagation.

- Ofcom's proposal is, to say the least, lacking in specifics. What would constitute a *"competition concern"* with the potential to require the relinquishment of spectrum? How could an operator subject to the cap "*satisfy us that the concern was being adequately addressed"*? (paragraph 9.89)

Vodafone believes that by the time the DDR spectrum in the upper band is available it will be substitutable with the 900 MHz band as an input the supply of mobile broadband services (or indeed any services). As in any market, there exists the possibility that 'competition problems' may emerge. However, Ofcom has not explained why its existing (ex post) remedies are inadequate to address any such issues. The auction of new spectrum should not be used as an opportunity to steer it towards the hands of a particular type of operator via some new sub-dominance threshold for intervention i.e., just in case competition is not "fully effective".

Question 44: Do you agree with our assessment that issues in the pay TV market are not at this stage primarily an issue for the cleared award?

No comment.

Question 45: Do you agree with our initial assessment that we should not intervene further in the cleared award to remedy any potential impact on competition resulting from the holding of cleared spectrum by NGW/Arqiva?

Ofcom also needs to consider the possibility that NGW/Arquiva could acquire spectrum for mobile services, or could acquire spectrum for broadcasting and subsequently change the use to mobile. NGW/Arquiva is uniquely able to manage such a transition, because it is likely that it would be the licence-holder for neighbouring spectrum that would need to agree to such a change of use.

Comments on Annex 5: Impact Assessment

In Para A5.2, Ofcom asks for comments on the Impact Assessment on its proposals in this consultation.

Vodafone wishes to make the following specific comments on this impact assessment:

1) This impact assessment considers the impact of individual elements of the proposal in this consultation document, but does not consider the impact of the proposal as a whole. The extreme complexity of the proposed auction design presents a substantial risk of regulatory failure or an inefficient outcome. Therefore, consideration of the contribution of individual elements of the proposal to its overall complexity would lead to different conclusions on some of these elements.

2) The assessment of the impact of spectrum caps does not take into account the discriminatory nature of these caps between operators with 900MHz spectrum and those with 1800MHz spectrum.

3) The assessment does not consider the alternative remedy of increasing the amount of substitutable spectrum in the UHF band.

4) The assessment does not consider the impact of incompatibility of the proposals with the likely CEPT bandplan for the 790-862MHz band.

5) Frequency size of lots:

- The assessment does not take account of the substantial difference in value for mobile between the upper and lower sub-bands as a result of all European developments being in the region of the upper sub-band.
- Different services, or mixes of services, result in substantially differing amounts of usable spectrum, due to the number and sizes of guard bands needed. In consequence, the value of the usable spectrum would need to be far higher for some permutations than others. Therefore, it is far more likely that the optimal outcome will have one service per sub-band than a mix of services.
- Once guard band conditions and the restrictions of channel 38 are taken into account, it is not feasible to deploy more than one viable mobile network in the lower sub-band.
- For the case of one mobile network in a sub-band, there is no loss in spectrum efficiency from offering the spectrum only in 8MHz lots. This is because the mobile operator would need to acquire a contiguous block of spectrum and the spectrum that would be unavailable to DVB-T or MMS would be a multiple of 8MHz.

For these reasons, there is no risk of regulatory failure from offering 8MHz lots in the sub-band and 5MHz (or 2X5MHz paired) lots in the upper sub-band.

6) Specificity of lots: the assessment does not consider the potential for specific lots to result in a very simple auction as well as a very complex one. The proposals in this response are one example of how specific lots can achieve this.

For our comments on other aspects of this impact assessment, please see the responses to the related questions.

Appendix 1

Detailed discussion of points made in response to question 28

1) As discussed in our answer to question 21, frequency generic lots are only needed where the partitioning of the spectrum is defined through the auction process. Generic lots are required to simplify the packages available to bidders, compared to creating a very large number of possible packages of frequency-specific lots. (It would clearly be infeasible to auction each 1MHz of the 144MHz of cleared spectrum as an individual frequency-specific lot, as that would create up to 2^144 packages to bid on!)

Vodafone's proposal for the lot types avoids the need both for generic lots and for a large number of packages. Our proposal would allow Ofcom to auction 14 frequency-specific lots - 8 in the lower sub-band and 6 in the upper sub-band - and to do so in separate auctions for the lower and upper sub-bands. There would then be at most 2^8-1 = 255 packages in the lower sub-band auction and slightly fewer than 2^6-1 = 63 packages in the upper sub-band auction (fewer if we assume that all the available packages assign paired spectrum contiguously).

If there were separate auctions, they might be run at different times, or concurrently. However, even if Ofcom decided to sell all 14 frequency-specific lots in a *single* auction, there would still be significantly fewer packages than for the recent 1452-1492 MHz (L Band) auction.

2) The consequence of generic lot types where there are significant remaining differences between the individual lots is to create bidder uncertainty in the Principal Stage. Bidders will not know at this stage which lots they will receive, and may be inclined to make "worst case" assumptions, and bid low accordingly. Consequently, bidders might be unable to bid for the specific lot or lot package that they really wanted at the Assignment Stage, even if they would have been prepared to make a high bid for that package at that stage. The result is an inefficient auction outcome.

3) The impact of trying to predict and mitigate these value differences is to create a very large number of lot types (35), and an enormous number of possible packages. (There will be less than ~2^35 because of the various package incompatibilities, but still much higher than for any auction conducted to date). The result is an auction design which is much *more* complex – and involves *more* uncertainty for bidders – than would an auction involving frequency-specific lots, as proposed above. Furthermore, even with such a large number of types, there are still very important value differences between lots considered to be of the same "type". (See also our answer to question 25).

While it is true that individual organisations would probably be interested in only a subset of the 35 lot types available, there is a real possibility of *commercially associated* bidders being interested in different types of lots. One part of the association may want broadcast spectrum, another may want to run a mobile network, a third may want to run a fixed wireless broadband network, a fourth MMS etc. Given that Ofcom's proposed qualification rules (see below) would require associated bidders to bid together as one group, the combined group could end up needing to make a very large and diverse collection of package bids.

Thus the auction would also call for a highly complex piece of software for capturing and verifying bids on the large number of packages, for extensive training in how to use the software, and possibly for long round-times to allow for bidders to enter their bids.

4) Vodafone is very concerned about Ofcom's preliminary estimates as to the complexity of the winner and price determination software (3 orders of magnitude more complex than for the L Band auction), and about the speculated need for parallel processing to compute the outcome in a reasonable time-frame. This leaves the concern that while Ofcom might (just) be able to calculate an auction outcome, no-one else could realistically do so.

In particular, bidders might be unable to run their own preparatory auctions over a range of scenarios, and calculate the likely results. Bidders would also be unable to run real-time "what if" scenarios during the primary rounds in an attempt to interpret the pattern of demand for various lot types, and use this to estimate the likely price they might have to pay, an estimation which could be critical to their decision about whether to reduce eligibility in the next round. If bidders are forced to bid without such estimates, they will not be able to benefit much from price discovery during the primary bid rounds, and so may be inclined to bid very conservatively.

Even without considering price discovery, bidders may be inclined to make the worst case assumption that what they will have to pay is close to what they bid, again encouraging conservative bidding. This could particularly impact on bidders with tight budget constraints – i.e. where there current budgets are somewhat lower than their ultimate valuations for the spectrum – and lead to inefficient outcomes.

5) A final point is that Ofcom is likely to have to answer questions after the auction about why the particular result emerged, and to explain the prices paid. Such questions will not be resolved simply by publishing the calculation tool and asking interested parties to run it themselves to verify the outcome (if they can acquire enough computing resource). Given the complexity of the auction, the justification may well involve a fairly lengthy report and detailed analysis.

Appendix 2

Realising the full 790-862MHz band for mobile in the UK

How channels 61, 62 and 69 can be released as digital dividend **09/07/08** **v 2.0**

Simon Pike

Summary

The UK proposals for release of digital dividend spectrum have become out of step with developments in Europe since WRC-07. In Europe, the focus is on the band 790-862MHz, but the UK only proposes to release 806-854MHz in this frequency range. However, this spectrum could not be used effectively, because it does not line up with any likely FDD bandplan. As a consequence, the bandwidth usable for mobile in UK within the digital dividend spectrum could be half or less of that available in other EU countries.

This paper discusses the technical feasibility and cost of releasing channels 61, 62 and 69 in UK, so that the full 790-862MHz band would be available. It proposes alternative frequencies to relocate TV channels 61 and 62 and the PMSE use in channel 69, while minimising the cost and disruption to broadcasters, viewers and PMSE users. The largest element of this cost is the possible replacement of reception antennas for viewers whose channels are moved within the UHF band. A technique is suggested that would substantially reduce the number of households that might be affected in this way. If this can be implemented, the total cost of releasing these channels would be ~£150 million or less. This is far less than the economic benefit of using this spectrum for mobile.

Introduction

The UK was the first EU country to draw up a detailed plan for digital switchover *and* release of digital dividend spectrum – this was done before the GE-06 conference. The proposed digital dividend spectrum is divided into two blocks (channels 31-40 and 63-68), largely because of the legacy of TV rooftop reception antennas only operating over part of the UHF band (a problem that is almost unique to UK). In UK, channel 69 (the top channel) is used exclusively by PMSE (programme making and special events - mainly radio microphones).

WRC-07 allocated the band 790-862MHz for mobile, and identified it for IMT. Since then, Sweden and France have made policy announcements that this band will be made available for mobile services. The recent Mandate from the European Commission to CEPT[28] requests CEPT to carry out technical investigations to define the technical conditions applicable for the sub-band 790-862MHz optimised for, but not limited to fixed/mobile communications networks.

The UK digital switchover is now out of step with developments in Europe since WRC-07. However, Ofcom does not appear to have reconsidered its plans in the light of the outcome of

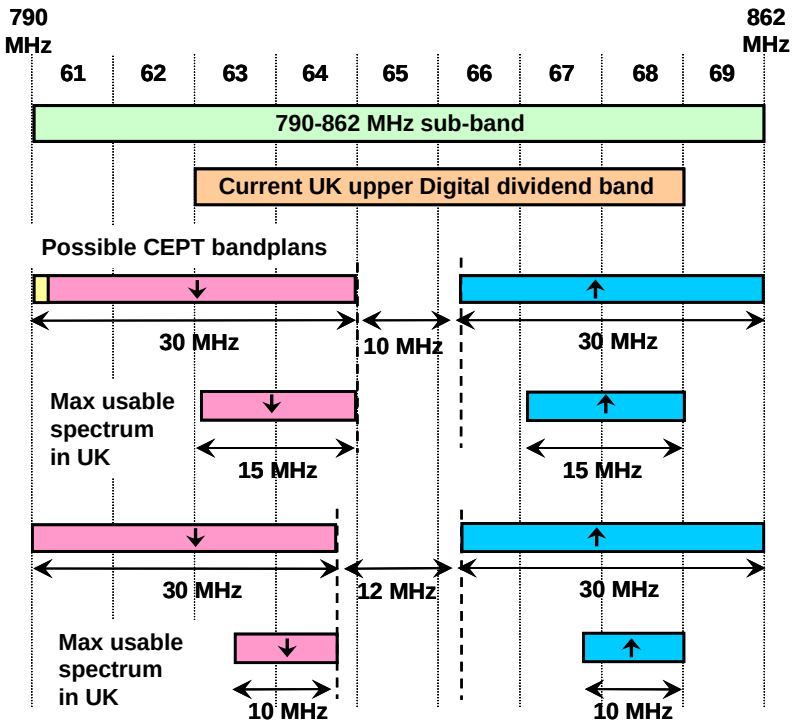
[28] Draft second mandate to CEPT on technical conditions regarding harmonisation options for the digital dividend in the European Union; RSCOM08-06 final.

WRC-07. For example, it has not conducted any economic studies of the economic benefit of releasing channels 61, 62 and 69 for mobile, compared to the cost of doing so[29]. The misalignment in the digital dividend between UK and the rest of Europe will seriously reduce the economic value of this spectrum for any use other than broadcasting.

This paper describes possible ways to include channels 61, 62 and 69 in the digital dividend in the UK, while minimising the cost and disruption to broadcasters, viewers and PMSE users.

The Need to release the full 790-862MHz band

The European Commission Mandate requests CEPT "to develop channelling arrangements that are sufficiently precise for the development of EU-wide equipment…" applicable for the sub-band 790-862MHz. The work on this started at the meeting of ECC PT1 on 14-16 May. At this meeting, the majority of stakeholders expressed their preference for paired spectrum. Half Duplex FDD has been proposed for this band, but many stakeholders believe that it is not well enough proven to rely on it. The most probable bandplans are 2 X 30MHz with a centre gap of 10MHz or 12MHz; a centre gap of 10MHz would allow a 2MHz guard band between mobile and broadcasting. Full duplex FDD terminals supporting this bandplan would not be able to operate in the frequency range of the duplex gap (even to support a different bandplan). In consequence, there could only be 2 X 15MHz of usable spectrum[30] in UK for the case of a 10MHz centre gap, and only 2 X 10MHz of usable spectrum for the case of a 12MHz centre gap[31]. This would be reduced to 2 X 10MHz and 2 X 5MHz respectively, with Ofcom's proposal for a 5MHz guardband between mobile downlink and DVB-T.



Releasing channels 61, 62 and 69 in UK would therefore at least double the amount of usable spectrum for mobile services.

[29] The launch of Channel 5 required modifications to the TV receiving systems in some households (in that case, retuning VCR modulator frequencies or installing a filter). As part of the plan for introduction of Channel 5, the IBA and ITC conducted detailed surveys of receiving systems and built a detailed economic model into its planning tool for the optimisation of the channel plan for Channel 5.

[30] Usable spectrum is spectrum that could be used nationally to support terminals developed for the CEPT bandplan.

[31] This would still require a different uplink/downlink separation to the CEPT bandplan, but this would be technically feasible.

Channels 61-62

The consequences of antenna grouping in UK

The release of channels 61 and 62 is complicated by the legacy of rooftop TV reception antennas that only operate over part of the band. In the early years of UHF broadcasting, most rooftop antennas did not cover the whole UHF band. The channels used on each transmitting site were grouped in part of the UHF band, and aerial installers selected the antenna "group" that covered that part of the band. When Channel 5 was launched, it was not always possible for the new channel to be within the same antenna group, so some viewers needed to install wideband antennas to receive Channel 5. The cost and performance difference of wideband antennas has diminished with time, and many new TV antennas are wideband.

If a channel is moved outside an antenna group, not all of the households within the service area of the transmitters will be affected. Most modern houses and many others will already have wideband antennas. Many other households will receive strong enough signals that the reduction in antenna performance will not affect reception.

In order to release channels 61 and 62 for mobile use, new frequencies must be found for the multiplexes on these channels. In most of the UK, the digital plan uses all available channels except the digital dividend spectrum. The obvious place to re-locate channels 61 and 62 is within the lower block of digital dividend spectrum, channels 31-40. However, most of the areas to be served by channels 61 and 62 have antenna group C/D, which only covers channels 48-68.

The cost of releasing channels 61 and 62

Vodafone has commissioned an independent study on the options for release of spectrum in the upper part of the UHF TV band. The report was commissioned before WRC-07, and considered two options for release of spectrum, 96MHz (channels 58-69) and 112MHz (channels 56-69). However, the results can easily be extended to the more modest case of 72MHz (channels 61-69). The report concluded that it is feasible to release up to 112MHz MHz of digital dividend spectrum (channels 56-69) in the upper part of the UHF TV band. The cost of infrastructure modifications would be around £50 Million, and the potential cost of replacing reception antennas is around £290 million (these values are relatively insensitive to the number of channels released – see the table below).

Cost of release of spectrum in UHF band for mobile

	96 MHz spectrum release	112MHz spectrum release	72MHz spectrum release (Vodafone estimate)	72MHz spectrum release with 2-stage migration (Vodafone estimate)
Infrastructure	47.49	49.52	40	45
Frequency Planning	2.5	2.5	2.5	2.5
Receiving antennas	290	290	270	50-100
Total (£ millions)	£339.99M	£342.02M	£312.5M	£97.5 – 147.5M

However, if only channels 61 and 62 are to be released, it appears possible to substantially reduce the cost or replacing reception antennas at the expense of a slight increase in the cost of infrastructure modifications. This is achieved by moving the channels of two sites at the same time in such a way that the neither site has channels moved across the boundary of its existing antenna group. This is described in more detail in annex 1.

If this technique can be applied, the total cost of clearing channels 61 and 62 could be reduced to around £100 – 150 million.

The lower digital spectrum comprises channels 31-40, except channel 38. Only six to seven of these nine channels would be needed for a national television multiplex. It would therefore be possible to relocate channels 61 and 62 into the lower digital dividend spectrum without reducing its usefulness for broadcasting.

Channel 69

The utilisation of channel 69 (854-862MHz) in UK by radio microphones is unique to UK[32]. All use of this spectrum by PMSE requires an individual licence, but there are two distinct classes of licence:

Shared channels: a licensee can use the channel anywhere in UK, without any protection from interference.

Coordinated channels: a licence is granted for a specific location, after coordination with other users.

We believe that suitable alternative spectrum can be made available for both shared and coordinated channels, which would exceed the spectrum currently available for PMSE in channel 69. Most modern radio microphones used in channel 69 also operate on other frequencies that will continue to be available for PMSE.

Shared channels

The users of shared channels in channel 69 are mainly small-scale professional users and hire companies. The small-scale users use a few channels, but desire better quality than available from the VHF channels, while the hire companies benefit from there not being a need for individual licence for each (possibly short term) hiring. The need for these shared channels has diminished with the availability of a pan-European band for radio microphones at 863-865MHz; the performance is comparable for most applications, and the equipment is cheaper because of the larger market.

There may be a continuing need for some users to have access to individually licensed shared channels. There are two potential bands for this purpose:

1) The 872-876MHz and 917-921MHz bands have been vacant since they were returned to Ofcom by Dolphin some years ago. This spectrum has not attracted much interest for possible licence award, and it is close enough to existing PMSE bands for equipment to be manufactured relatively easily; indeed some commercially available radio microphones already cover this frequency range.

[32] A few other EU countries may authorise the use of radio microphones in channel 69, but the mix of individually licensed shared and coordinated channels appears to be unique to UK.

2) The mobile bandplan for the digital dividend is expected to be based on paired spectrum. There will be a centre gap between the uplink and downlink bands of around 8-12MHz (at around channel 65, centred at around 825MHz), which would be appropriate for radio microphones.

Almost all recent radio microphones for Channel 69 also operate in the 863-865MHz band, so could continue to be used if channel 69 was withdrawn from PMSE use.

Coordinated channels

The coordinated channels in channel 69 are similar in licence conditions and technical characteristics to the coordinated channels in interleaved spectrum in other parts of the UHF band. The population of users will therefore be very similar – mainly large-scale professional users. Most recent professional radio microphone equipment tunes over a number of TV channels, and could continue to be used if channel 69 was withdrawn from PMSE use.

It is not clear that the digital switchover will reduce the availability of interleaved spectrum for PMSE. While the number of broadcast channels will reduce, the greatly increased robustness of DVB-T to interference will mean that the utilisation of the interleaved spectrum can be significantly increased. We believe that these two factors will roughly cancel out. The coordinated use that formerly used channel 69 could therefore be accommodated in the interleaved spectrum.

The 872-876MHz and 917-921MHz bands and the centre gap of the mobile band would also be suitable for coordinated radio microphone channels.

Cost of relocating Channel 69 microphones

The Sagentia report on PMSE in the UHF band[33] estimated that there are around 20, 000 radio microphones licensed for use in channel 69 in UK[34]. The typical purchase cost of the frequency dependent parts of a professional radio microphone system is around £500[35] per channel. Therefore, the maximum cost of relocating PMSE from channel 69 to another band would less than £10 million. However, the current asset value will be substantially less, and many of the microphones could continue to be used on other frequencies.

[33] Use of UHF spectrum for Programme Making and Special Events in UK; Sagentia; 13 December 2006

[34] A proportion of the microphones for shared channels will be used on other channels.

[35] Many parts of a radio microphone system are frequency independent, including tieclip microphones, racks and remote monitoring equipment.

ANNEX 1

CHANNEL CHANGES REQUIRED TO RELEASE CHANNELS 61 AND 62 NATIONALLY

The table below shows the channel changes that would be needed to release channels 61 and 62 nationally. The affected households are those where the channel change results in channels outside the range of an existing antenna group (this only occurs when the existing antenna group is C/D). In practice, only a small proportion of these households would need a new antenna, as most newer UHF TV antennas are broadband, and the majority of households with older antennas will receive a strong enough signal that the reduction in antenna performance will not affect reception.

The last two columns show a possible way to reduce the number of potentially affected households, by moving channels 61 and 62 on to lower channels, still within the Group C/D range, used at a neighbouring site. The channels on the neighbouring site would be moved down to the channel 31-40 range. This "two stage" approach would mean that neither the change of channel nor the consequential change in channel on the neighbouring site would result in a change of antenna group.

In the table below, this technique has been applied to Winter Hill and Pontop Pike, with consequential channel changes for Emley Moor and some smaller sites. There are some other sites where it appears possible to make this change without needing any consequential changes to other sites.

These proposals are based on a visual inspection of the channel plan, and would need to be confirmed using coverage planning tools. It may be possible to apply the same approach to other sites (for example, swapping channel 61 at Mendip with channel 49 at Wenvoe).

Ref.	Site	Switchover Channels	Rx Antenna Group	Net Households	Channel changes (notes 1, 2)	Affected Households	Different channel changes 2 stage *	Affected Households 2 stage
10100	Crystal Palace	23,26,30,25,22,28	A	4,219,500		0		0
10101	Guildford	43,46,49,48,52,56	C/D	45,500		0		0
10103	Reigate	53,57,60,21,24,27	W	68,400		0		0
10104	Tunbridge Wells	49,52,47,42,44,41	B	50,200		0		0
10105	Hemel Hempstead	41,44,47,62,59,55	E	70,800	62→31-40	0		0
10200	Sutton Coldfield	43,46,50,42,45,49	B	1,706,400		0		0
10203	Brierley Hill	53,57,60,62,59,55	C/D	84,000	62→31-40	84,000		84,000
10206	Bromsgrove	23,26,30,41,44,47	K	28,400		0		0
10207	Malvern	53,57,60,62,59,55	C/D	57,900	62→31-40	57,900		57,900

Ref.	Site	Switchover Channels	Rx Antenna Group	Net Households	Channel changes (notes 1, 2)	Affected Households	Different channel changes 2 stage *	Affected Households 2 stage
10208	Lark Stoke	23,26,30,41,44,47	K	36,600		0		0
10211	Fenton	21,24,27,25,22,28	A	126,100		0		0
10300	Winter Hill	62,59,54,58,61,55	C/D	2,543,900	61, 62→31-40	2,543,900	61, 62→51, 52	0
10302	Pendle Forest	28,25,22,27,21,24	A	44,600		0		0
10306	Saddleworth	45,49,42,51,52,48	B			0	51, 52→31-40	0
				10,200			(Note 2)	
10307	Storeton	28,25,22,23,26,29	A	44,800		0		0
10335	Lancaster	27,24,21,25,28,22	A	50,200		0		0
10400	Emley Moor	41,44,47,51,52,48	B	1,425,900		0	51, 52→31-40	0
10403	Sheffield	21,24,27,42,45,49	K	109,400		0		0
10405	Chesterfield	23,26,29,43,46,50	K	23,600		0		0
10407	Keighley	54,58,61,57,53,60	C/D	32,800	61→31-40	32,800		32,800
10413	Idle	21,24,27,42,45,49	K	20,400		0		0
10500	Black Hill	43,46,50,41,44,47	B	883,600		0		0
10510	Torosay	22,25,28,23,26,29	A	2,550		0		0
10600	Wenvoe	41,44,47,42,45,49	B	338,500		0		0
10601	Kilvey Hill	23,26,29,25,22,28	A	118,300		0		0
10606	Aberdare	21,27,24,25,22,28	A	17,600		0		0
10615	Pontypool	23,26,29,25,22,28	A	24,100		0		0
10700	Divis	27,24,21,23,26,29	A	423,400		0		0
10800	Rowridge	24,27,21,25,22,28	A	636,000		0		0
10801	Salisbury	57,60,53,62,59,55	C/D	30,200	62→31-40	30,200		30,200
10805	Whitehawk Hill	53,57,60,51,56,48	C/D	102,700		0		0
10900	Pontop Pike	54,58,61,62,59,55	C/D	652,100	61, 62→31-40	652,100	61, 62→51, 52	0
10903	Fenham	21,24,27,25,22,28	A	31,800		0		0
11000	Mendip	54,58,61,48,52,56	C/D	706,900	61→31-40	706,900		706,900
11007	Bristol Kings Weston	43,46,50,53,57,60	C/D	18,600		0		0
11008	Bristol Ilchester Cres	41,44,47,42,45,49	B	25,200		0		0
11100	Waltham	54,61,58,29,56,57	W	745,200	61→31-40	0		0
11101	Nottingham	21,24,27,51,52,48	W	69,900		0		0

Ref.	Site	Switchover Channels	Rx Antenna Group	Net Households	Channel changes (notes 1, 2)	Affected Households	Different channel changes 2 stage *	Affected Households 2 stage
11200	Durris	22,25,28,23,26,29	A	165,300		0		0
11300	Dover	50,53,51,55,59,62	C/D	247,300	62→31-40	247,300		247,300
11400	Tacolneston	55,59,62,42,45,50	E	369,600	62→31-40	0		0
11500	Sudbury	41,44,47,58,60,56	E	431,100		0		0
11600	Bilsdale	23,26,29,43,46,50	K	574,300		0		0
11700	Oxford	53,57,60,62,59,55	C/D	419,000	62→31-40	419,000		419,000
11800	Llanddona	57,60,53,43,46,50	C/D	53,400		0		0
11900	Carmel	57,60,53,54,58,61	C/D	67,700	61→31-40	67,700		67,700
12000	Belmont	22,25,28,30,53,60	W	705,000		0		0
12002	Olivers Mount	53,57,60,54,58,61	C/D	29,800	61→31-40	29,800	61→51	0
12100	The Wrekin	23,26,30,41,44,47	K	261,800		0		0
12300	Angus	57,60,53,54,58,61	C/D	124,200	62→31-40	124,200	61→51	0
12400	Sandy Heath	21,24,27,51,52,48	W	862,500		0		0
12500	Midhurst	61,55,58,62,59,50	C/D	99,900	61→31-40	99,900		99,900
12600	Hannington	42,45,51,41,44,47	B	526,200		0		0
12900	Presely	46,43,50,42,45,49	B	56,300		0		0
13000	Limavady	55,62,59,54,58,61	C/D	47,000	61, 62→31-40	47,000		47,000
13100	Caradon Hill	28,25,22,21,24,27	A	182,800		0		0
13105	Plympton	54,61,58,42,45,56	E	32,700	61→31-40	0		0
13200	Stockland Hill	26,23,29,25,22,28	A	127,600		0		0
13400	Keelylang Hill	46,43,50,42,45,49	B	8,800		0		0
13402	Bressay	22,28,25,27,24,21	A	5,700		0		0
13500	Blaenplwyf	21,24,27,25,22,28	A	16,900		0		0
13600	Beacon Hill	60,53,57,42,45,51	E	83,800		0		0
13700	Caldbeck	28,25,30,23,26,29	A	124,300		0		0
13800	Huntshaw Cross	62,59,55,48,52,56	C/D	37,000	62→31-40	37,000		37,000
13900	Heathfield	49,52,47,42,44,41	B	214,200		0		0
13902	Hastings	22,25,28,23,26,30	A	20,100		0		0
14100	Redruth	44,41,47,48,52,51	B	89,900		0		0

Ref.	Site	Switchover Channels	Rx Antenna Group	Net Households	Channel changes (notes 1, 2)	Affected Households	Different channel changes 2 stage *	Affected Households 2 stage
14500	Moel Y Parc	42,45,49,51,52,48	B	113,500		0	51, 52→31-40	0
14700	Craigkelly	21,24,27,42,45,49	K	422,300		0		0
14800	Rumster Forest	21,24,27,30,59,62	W	20,400	62→31-40	0		0
14900	Ridge Hill	22,25,28,21,24,27	A	272,800		0		0
15100	Brougher Mountain	22,28,25,21,24,27	A	39,600		0		0
15200	Darvel	22,25,28,23,26,29	A	145,000		0		0
15211	Rosneath VP	54,58,61,53,57,60	C/D	37,500	61→31-40	37,500		37,500
15300	Knockmore	23,26,29,53,57,60	W	31,200		0		0
15400	Eitshal	26,23,29,25,22,28	A	9,100		0		0
15500	Chatton	42,45,49,41,44,47	B	26,000		0		0
15600	Rosemarkie	45,49,42,43,46,50	B	59,500		0		0
15800	Bluebell Hill	43,54,46,45,48,61	C/D	197,600	61→31-40	197,600		197,600
16100	Selkirk	62,59,55,57,53,60	C/D	22,600	62→ 31-40	22,600	62→52	0
	TOTAL			23,007,550		5,437,400		2,064,800

RX Antenna Groups

Group	Frequency channels
A	21-37
B	35-53
C/D	48-68
E	35-68
K	21-47
Wideband	21-68

Note 1: There are usually several possible channels with the 31-40 range.

Note 2: Antenna groups B and E only extend down to channel 35, but the vast majority of these antennas perform well on channel 34.

* Only additional or different channel changes are shown