OFFICE OF COMMUNICATIONS

Award of available spectrum: 2500-2690 MHz, 2010-2025 MHz and 2290-2300 MHz

This document consults on Ofcom's proposals for the grant of wireless telegraphy licences to use these spectrum bands and for the method of award

Consultation

Publication date: 11 December 2006

Closing Date for Responses: 9 March 2007

Contents

Section 1

Executive summary

1.1 Ofcom has developed a programme of awards of wireless telegraphy licences that is designed to put unused or under-used spectrum into the market as part of its strategy of ensuring optimal use of the radio spectrum. This consultation document sets out in detail Ofcom's proposals for the award of wireless telegraphy licences to use the three spectrum bands at 2500-2690 MHz, 2010 MHz -2025 MHz and 2290-2300 MHz (referred to as the 2.6 GHz band, 2010 MHz band and 2290 MHz band respectively).

1.2 The award of this spectrum will play a key role in the implementation of Ofcom's strategy of spectrum release, comprising 215 MHz out of around 400 MHz of spectrum below 3 GHz that is planned to come to market as a primary offering over the next few years. Of the bands under consideration the most important is the 2.6 GHz band which represents 190 MHz. The bulk of the discussion in this consultation therefore focuses on this band. However, the 2010 MHz and 2290 MHz bands also represent important opportunities for value creating spectrum use and they are covered fully in this consultation document. The reason for consulting on the three bands as part of one award programme is that they are potential substitutes for each other for a number of candidate applications and they are able to be made available together.

1.3 The Spectrum Framework Review: Implementation Plan (SFR:IP), published in January 2005[1], consulted on both the overall programme of spectrum awards and on some more specific matters relating to these particular bands. Ofcom's position was updated in an Interim Statement on the SFR:IP in July 2005[2] in light of responses to the SFR:IP. Since then Ofcom has undertaken considerable further work:

a) to investigate the prospective demand for these bands and the economic benefits that might arise from bringing them into use;

b) on the technical conditions under which the bands might be used taking into account the candidate technologies and the need to manage interference with adjacent users; and

c) on the means of packaging the spectrum and the design of auction mechanisms under which the spectrum might be awarded.

Demand assessment

1.4 The three bands for award are either unused at present or expected to become available for new applications as from the beginning of 2007.

1.5 The market research has identified four main categories of services for which prospective operators have indicated an interest in using these bands.

[1] The consultation and responses are available at http://www.ofcom.org.uk/consult/condocs/sfrip/sfip/.
[2] See http://www.ofcom.org.uk/consult/condocs/sfrip/statement/.

a) Advanced mobile telephony services using 3G technologies and their evolutions (UMTS FDD, HSPA and Long Term Evolution) which are optimised for a mix of voice and data traffic. These would allow the further development of mobile telephony and data services currently available in the UK.

b) Broadband wireless services using WiMAX standards (2005/revision e in particular) or a variant of the 3G family (UMTS TDD) which are optimised for carrying data with Voice over IP (VoIP) calls as one data application. These would allow the delivery of high data rate services to fixed, nomadic or mobile devices.

c) Mobile multimedia services that could complement cellular or broadband wireless services or be stand-alone services. Using specific additional applications based on MBMS or TDtv for example, services like mobile television could be delivered to cellular or broadband wireless terminals. A service could also be delivered using technologies such as DVB-H or DMB. Any of these technologies could potentially allow the delivery of broadcast content to portable multimedia devices.

d) Programme Making and Special Events (PMSE) services, primarily for digital video applications (e.g. wireless cameras, temporary links, mobile or portable links), enabling such activities as news coverage and the broadcasting of planned events, for example concerts or football games.

1.6 The release of these bands for some or all of the above services is likely to enable significant benefits to consumers to be realised in the form of:

a) innovations in relation to new or improved services and applications that operators may be able to offer;

b) opportunities for new entry into the relevant downstream markets, offering services in competition with the existing operators which could result in price reductions and more consumer choice for services; and

c) cost savings for the existing operators which are likely to be passed on to consumers in the form of price reductions, given the relatively competitive nature of these markets.

1.7 Although estimates of the size of these benefits are uncertain by their nature, our analysis suggests that the benefits would be substantial.

1.8 Given this, it would seem desirable to begin to take the necessary steps now to allow the 2.6 GHz, 2010 MHz and 2290 MHz bands to be brought into use for new applications.

Timing of Award

1.9 The benefits referred to above can only be delivered once the bands have been made available for use. The potential size and scope of the benefits suggest that the bands should be released as soon as possible. Ofcom considers that this could be achieved by the end of 2007 on the basis of the proposals set out in this consultation.

1.10 However, there are a number of factors that could impact on this timetable. In particular, it is possible that work on harmonisation measures at a European level over the course of the next year could impact the way in which the UK is able to progress with these proposals (see paragraphs 1.18 to 1.20 below). Future developments at European level are uncertain and it should be recognised that these could be a source of delay in the award, perhaps into 2008.

1.11 Another consideration relates to other spectrum that could become available to be used to provide the same or similar services (i.e. potential alternatives to the 2.6 GHz, 2010 MHz and 2290 MHz bands). Other spectrum that could be relevant in this context includes:

a) spectrum that is expected to become available following Digital Switchover (which will be detailed in the forthcoming Digital Dividend Review consultation);

b) spectrum that may be released by public sector users following the implementation of the recommendations of the Independent Audit of Spectrum Holdings of 2005[3];

c) spectrum that is currently licensed for use only by 2G technology (GSM), but which is expected to become available in due course to be re-used for other technologies in keeping with Ofcom's general policy of promoting technology neutrality; similar considerations apply to existing spectrum licences currently for 3G-only use;

d) spectrum at 1452-1492 MHz which Ofcom expects to bring to the market next year, but which is also subject to some uncertainties at European level; and

e) a range of other bands which form part of Ofcom's future award programme.

1.12 It has been put to us that the award of the 2.6 GHz band (in particular) should be deferred until such time as there is certainty in relation to the availability of, and terms of use for, at least some of this potential alternative spectrum. Ofcom has considered this point carefully. However, we judge that there is a balance to be struck, in this and other cases, between pursuing the reduction of uncertainty and releasing spectrum promptly so that it can start to be used to the benefit of citizens and consumers.

1.13 The assessment in this consultation document is that there is keen demand for access to these bands as soon as possible. This demand comes principally from potential new entrants and competitors to established operators. It is also clear that no benefits can flow from use of the bands until new rights to use have been awarded. This points towards prompt release of the spectrum with minimum delay.

1.14 On the other hand, it is possible that a delay in the award could lead to a reduction in some of the uncertainties identified above. It is also true that reductions in uncertainty can be beneficial, as they can allow better-informed choices about the use of resources. However, delaying the award of the bands until certainty is reduced is likely to have large costs, as none of the potential benefits from use of the spectrum will be available to citizens and consumers during the delay. Moreover, the extent to which delay might reduce uncertainty may itself be uncertain – both as to the extent of the delay and the extent of the reduction in uncertainty.

1.15 In light of these considerations, Ofcom's view in this consultation is that it should seek to reduce uncertainty that exists in relation to other bands wherever feasible, but it should do so without delaying the awards covered in this document.

[3] The Audit, led by Professor Martin Cave at the request of Government, was conducted with a view to identifying spectrum used by public sector bodies that could be released to the market.

1.16 This is similar to the approach that Ofcom and the Radiocommunications Agency have taken in previous spectrum awards. Many spectrum bands are to some extent substitutable resources. It is therefore inevitable that potential participants in any award process will face uncertainty in relation to the future availability of alternative spectrum. This will be true both as it relates to spectrum that might become available through Ofcom's award programme, and to spectrum that might become available through secondary markets from existing users in the public or private sector. Uncertainty will also inevitably exist in relation to future regulation at national and European level.

1.17 Potential new entrants, who might be looking to acquire spectrum, will be affected by these uncertainties, as well as established operators. Ofcom considers that a principal means by which uncertainty can be reduced for all parties is by ensuring that as much information is available as possible about the likely availability of other bands, Ofcom's policies on spectrum management, and the wider regulatory framework. Ofcom will pursue this task as an important part of the award programme.

International issues

1.18 The 2.6 GHz band in particular has been, and continues to be, the subject of discussions in various European regulatory fora. These discussions broadly reflect the existence of two different points of view. The first, which the UK supports along with a number of other countries, favours a technology neutral approach towards spectrum usage. The second favours a more technology specific approach towards spectrum management and, in respect of the 2.6 GHz and 2010 MHz bands in particular, favours the limitation of their use to IMT-2000[4] technologies. The relevant European regulatory bodies in this context are the European Conference of Postal and Telecommunications Administrations (CEPT)[5] and the Radio Spectrum Committee (RSC), where the position is as follows.

a) CEPT, the European regulatory body where technical provisions for spectrum use are considered by 47 member states, has adopted several Decisions in recent years that reflect the more technology specific point of view, despite the divergence of views between its members on this subject. In particular, two CEPT Decisions include restrictions on the use of the 2.6 GHz and 2010 MHz bands that designate the bands for IMT-2000 technologies and one of these Decisions organises the 2.6 GHz band according to a fixed band plan that identifies specific blocks for technologies using paired spectrum and another block for technologies using unpaired spectrum. However, members of the CEPT are not required to implement CEPT Decisions and the UK has chosen not to implement these particular CEPT Decisions.

b) The European Union's (EU) RSC has the power to make Decisions on spectrum use that are binding on its 25 member states. Over the past year the European Commission has put forward proposals for a binding RSC Decision in relation to the 2.6 GHz band. However, in light of the opposing views on technology neutrality referred to above, it has not been possible to reach sufficient agreement amongst member states for an RSC Decision to be adopted. The Commission has therefore decided to withdraw its proposals. Instead, it has

[4] IMT-2000 is a term which refers to a family of technologies that is identified by the ITU. It currently includes 5 categories: UMTS FDD (paired), UMTS TDD (unpaired), cdma2000, EDGE and DECT. Some technologies that are plausible uses for the available bands are not included at present such as WiMAX (IEEE 802.16), iBurst (HC-SDMA), FLASH-OFDM or PMSE technologies.

[5] See http://www.cept.org/.

included the 2.6 GHz band in a mandate issued to the CEPT to prepare a technical study on the use of a number of bands for mobile communications under the least restrictive technical conditions.

1.19 CEPT is due to report back to the Commission on the above mandate in July 2007. The RSC is expected to consider its approach towards the 2.6 GHz band again at meetings thereafter; in addition, the Commission may bring back to RSC its original proposals for harmonisation or variant thereof. The potential exists for this process to lead, ultimately, to the RSC making a Decision on the spectrum in a way that constrains the manner in which the 2.6 GHz band can be used.

1.20 The UK does not need, as a binding constraint, to wait for an RSC Decision before proceeding to the award of these bands in the UK; indeed, it is possible that a continued lack of consensus amongst the member states may make it difficult for the RSC to reach a binding Decision on these bands. Ofcom will take full account of any developments in the European regulatory fora during the course of 2007 in deciding whether to proceed with the release of these bands in the UK, in the timescale and in the manner proposed in this consultation, including the possible timing of any future RSC Decision and of the likelihood that any future RSC Decision may conflict in some respects with the approach set out in this document. Ofcom's current view, although events could cause this to change, is that the prospective developments in the European position over the coming year are likely to be consistent with an award as proposed in autumn 2007.

Overview of key proposals

1.21 A key issue for the design of the award concerns the degree of flexibility in the way that the 2.6 GHz band can be used and the amount of unpaired spectrum and paired spectrum[6] there should be in the band. Ofcom considers that regulators are ill-placed to judge the appropriate balance between these alternative uses of spectrum. Moreover, this is a decision that can be left to the market. This is a key element of the proposals in this document.

1.22 In these proposals, we take as a starting point the CEPT band plan which divides the spectrum into blocks of paired and unpaired channels (illustrated in the diagram below). Some features of the CEPT band plan are included in Ofcom's proposals (such as a duplex spacing of 120 MHz between paired channels); this should allow the relevant degree of technical compatibility between equipment that is likely to be used in the UK and internationally. However, in keeping with Ofcom's strategy of promoting a technology and service neutral approach where possible, and in light of evidence that there is considerable interest in deploying technologies other than IMT-2000 in these bands (which could lead to a larger requirement for unpaired spectrum than allowed for in the CEPT band plan), we are proposing to:

a) specify usage rights in a way which will allow any technologies to be deployed (but with relevant technical requirements to avoid harmful interference); and

b) design the award process in such a way that the split between paired and unpaired spectrum can reflect the relative demand for each as revealed through

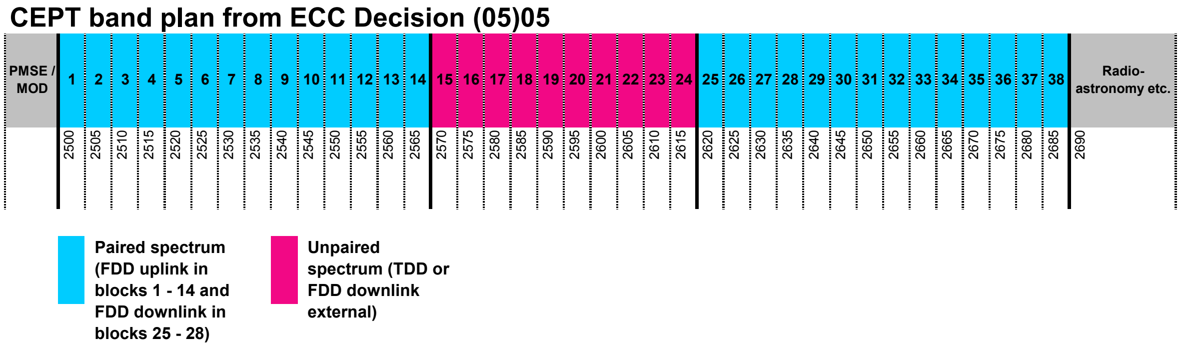
[6] When using "paired" channels the uplinks, from handsets to base station, and the downlinks, from base station to handsets, take place at different frequencies to avoid interference (this is called FDD). An "unpaired" channel can be used for one-way transmission (e.g. mobile TV) or for two way communication where the uplink and downlink take place at the same frequency, but are separated by timeslots i.e. a burst of uplink followed by a burst of downlink (this is called TDD).

the auction (rather than lock in a pre-determined split which could well turn out to be economically sub-optimal).

1.23 In view of this, the main proposals for packaging the spectrum in the 2.6 GHz band are as follows.

a) Division of the spectrum into two types of lot which mirror the CEPT band plan to the extent necessary, as illustrated in the figure below. The first type of lot consists of a single, unpaired[7] 5 MHz channel in the central part of the band from 2570-2620 MHz. The second type of lot consists of a pair of 5 MHz channels with a duplex spacing of 120 MHz. In addition, there needs to be a third category that reflects the need for guard channel(s) between the adjacent technologies (although these are not reflected in the CEPT band plan below).

Figure 1: CEPT band plan from ECC Decision (05)05 with predetermined amounts of paired and unpaired spectrum

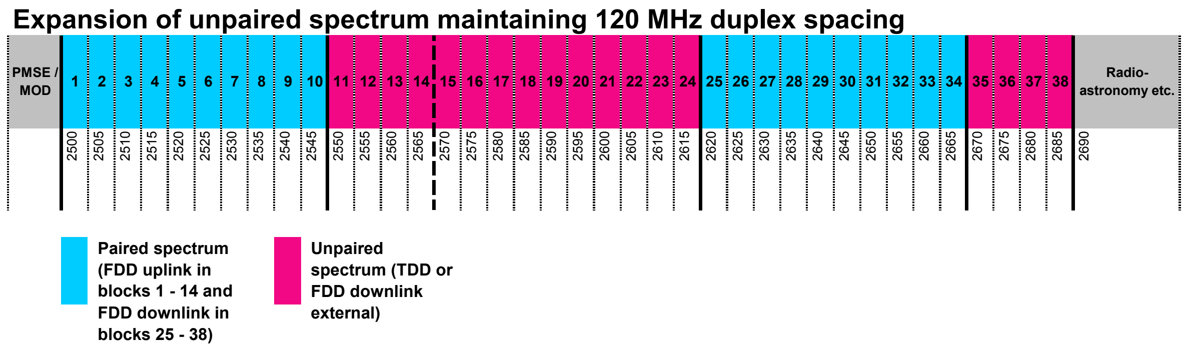


b) Allow the paired lots to be converted into the equivalent of two unpaired lots through the operation of the auction rules if the relative demand for paired and unpaired spectrum indicates that this would be efficient.

1.24 There are two ways in which this could be translated into the resulting band plan. The first approach, and the one we propose to adopt, would be to accommodate additional unpaired spectrum at the top of the 2.6 GHz band. This has the advantage of preserving the 120 MHz duplex spacing for the paired spectrum (as in the diagram below) but the disadvantage that it could require an extra guard channel.

[7] These lots are referred to as "unpaired" as they are not paired with other channels *within* the 2.6 GHz band. However, a successful bidder could choose to pair these with other spectrum *outside* the 2.6 GHz band, e.g. with spectrum in the 2010 MHz band.

Figure 2: Illustration of the expansion of the amount of unpaired spectrum at the top end of the 2.6 GHz band relative to the CEPT band plan (duplex spacing of 120 MHz)



1.25 The alternative approach would be for the central block of unpaired channels to be expanded in both directions. This would avoid the need for an extra guard channel, but at the expense of requiring a duplex spacing for paired lots that differs from 120 MHz.

1.26 It is proposed that the licences be awarded by auction. Ofcom considers that a simultaneous multiple round auction (SMRA) design is likely to be most appropriate for the award of this spectrum band. Ofcom has prepared detailed auction proposals on which it is seeking views through this consultation. A key feature of the particular design being proposed is that it breaks the auction into two stages.

- In the first stage, bidders compete for generic lots of paired and unpaired spectrum that are not linked to any particular frequencies. This resolves how the 2.6 GHz band will be split between paired and unpaired uses and how many spectrum blocks bidders receive.

- In the second stage – the assignment stage - successful bidders from the first stage can express any preference they might have for particular frequencies. The generic lots won by each successful bidder in stage 1 are converted into identified channels at specific frequencies. This stage involves the submission of sealed bids for a number of alternate packages of channels at specific frequencies (each of which are of a size that equates to the volume allocation that a bidder won in the first stage).

1.27 Turning to the 2010 MHz band, Ofcom's main proposals are as follows.

a) Package this band as a single 15 MHz block since the usage rights that would have to be imposed on separate 5 MHz channels would be so restrictive as to severely impair any potential use.

b) Award this lot as part of the same process as the 2.6 GHz auction since these bands could be close substitutes[8]; in practice, this can be achieved by including 2010-2025 MHz as a separate type of lot within the first stage of the auction with its own price during the clock stage, but with bidders allowed to switch demand between the 2010 MHz lot and the unpaired lots in the 2.6 GHz band in accordance with specific rules.

[8] These bands could also be close complements if a bidder wished to pair 2010 MHz spectrum with unpaired channels in the 2.6 GHz band in order to deploy FDD technology with a non-standard duplex spacing.

1.28 In the case of the 2290 MHz band, Ofcom's main proposals are as follows.

a) Make available a 10 MHz block for award (2290-2300 MHz) as market testing suggests that the demand is for a block of this size, rather than the full 12 MHz available. The remaining 2 MHz can be held for inclusion in a later award should the current status of the spectrum above 2302 MHz change.

b) Award this spectrum as part of a distinct process that is in advance of the 2.6 GHz and 2010 MHz auction. This proposal reflects the expectation that this spectrum is a much weaker potential substitute for the other 2.6 GHz and 2010 MHz bands, except potentially for prospective PMSE users.

c) Award the lot under a second price, sealed bid approach, although an SMRA could be an alternative option.

1.29 It is proposed that the key elements of the licensees' rights and obligations for the spectrum to be auctioned in all three bands should be as follows.

a) The licences should have an indefinite term with a minimum period of 20 years (during which time Ofcom's powers to revoke will be limited).

b) The licences should be tradable.

c) The licences should be technology and application neutral.

1.30 We are consulting on two possible approaches for defining the technical conditions associated with each lot.

a) Using spectrum masks for transmission rights.

b) In terms of Spectrum Usage Rights that are in keeping with our recent information notice in this regard[9].

Detailed summary of Ofcom's proposals

1.31 The table below sets out in summary form Ofcom's proposals for this award.

Timing	**Ofcom proposals**
Timing and linkage of awards	All three bands to be awarded as soon as practicable. The 2.6 GHz and 2010 MHz bands to be awarded as part of the same auction, with the 2290 MHz band being awarded in advance as part of a separate auction.
Spectrum packaging	**Ofcom proposals**
2500-2690 MHz	Packaged on the basis of blocks of 5 MHz as lots of paired spectrum (2x5 MHz, 120 MHz duplex spacing) and unpaired spectrum (5 MHz), with the eventual amount of lots in each category to be determined in the auction. The reference point is as per the CEPT band plan: 14 lots of paired channels (14x2x5 MHz with uplink in 2500-2570 MHz and downlink in 2620-2690 MHz) and

[9] See the update of 1 November 2006, available at http://www.ofcom.org.uk/consult/condocs/sur/next_steps2/.

	9 lots of unpaired channels (9x5 MHz in 2570-2615 MHz). One guard channel will be necessary at adjacencies between paired and unpaired spectrum, at 2615-2620 MHz, and possibly another in the top part of the band. Allow paired lots to be converted into the equivalent of two unpaired lots in the event that demand for unpaired lots exceeds that for paired lots at a given lot price. Each bidder to receive contiguous lots in each category, except potentially one assignment of unpaired spectrum which could need to be split into two blocks of contiguous lots.
2010 MHz -2025	Package for award as a single 15 MHz lot.
2290-2302 MHz	Package for award as a single 10 MHz lot and retain 2300-2302 MHz for possible inclusion as part of a future award together with 2302-2310 MHz.
Wireless Telegraphy rights and obligations	**Ofcom proposals**
Licence term	The licences will have an indefinite duration, with an initial term of 20 years for the 2.6 GHz, 2010 MHz 2290 MHz bands during which Ofcom's powers to revoke will be limited. Ofcom will have the power to revoke for spectrum management reasons on not less than 5 years' notice after the initial term, which could lead to the licence being terminated the day after the expiry of the initial term or at any time thereafter.
Licence fees	The auctions will determine the fees payable, subject to a reserve price. After the expiry of the initial term, if a licensee continues to hold its licence, there may be additional charges in line with Ofcom's policy on spectrum pricing at that time.
Spectrum trading	The licences will be tradable. All types of trade - partial or total; concurrent or outright - will be permitted.
Liberalisation	The licences will contain the minimum necessary technical conditions and will not specify either the technology to be used or the services that may be offered.
Technical conditions	These are intended to be the minimum necessary to ensure effective use of the licensed frequencies, controlling interference between different authorised uses. The technical conditions will comprise a constraint on use defined either by Spectrum Usage Rights or by reference to Spectrum Masks. Rights to use the frequency will be on a UK-wide basis within the defined frequency range of each licence.
Award mechanism and rules	**Ofcom proposals**
Auction format for the 2.6 GHz and 2010 MHz bands	Two-stage award process with first stage being a multi-round clock auction with three types of generic lots (paired channels in 2.6 GHz band, unpaired channel in 2.6 GHz band and a lot representing the 2010 MHz -2025 MHz band), and the second stage being a sealed bid process to convert the generic lots won in the first stage into packages of spectrum at specific frequencies in the 2.6 GHz band.

Auction format for the 2290 MHz band	Second price, sealed bid auction
Eligibility rules for auction of the 2.6 GHz and 2010 MHz bands	Each lot in the auction will have an associated number of eligibility points with each lot in a given type attracting the same number of points. The number of lots on which bidders can make bids would be constrained by their eligibility, which in turn is determined by their initial eligibility and bidding activity over multiple rounds
Reserve price	Ofcom will set a reserve price above zero for each individual lot. Bids in both proposed auctions will need to be higher than the reserve prices.
Deposits	Ofcom will set an initial level of deposit per eligibility point. Each bidder's initial eligibility will thus be determined by the level of deposit that they have paid before the auction. A mechanism will be introduced to ensure that bidders increase their deposits in a way that reflects their aggregate bid levels at set points during the 2.6 GHz / 2010 MHz auction and at the bidding stage in the 2290 MHz auction.
Payment terms	Winning bidders will be required to pay 100% of the fee for their licence by a specified time and the licences will only be granted after payment has been received.
Transparency	In the 2.6 GHz / 2010 MHz auction the identity of the bidders will be made public. Information on the volume of bids will be released after each round. Prices at which lots are awarded after stage 2 will be published. At the end of the auction, all bids made, including best and final offers and stage 2 bids, and the prices paid by the winning bidders will be published. In the 2290 MHz auction, the identity of the bidders will be made public. However, upon completion, only the amount paid by the winning bidder will initially be published. The detail of all bids will only be published when the 2.6 GHz / 2010 MHz auction is completed.
Pace of the 2.6 GHz / 2010 MHz auction	Rules will be deployed to give Ofcom flexibility in managing the pace of the auction.
Prohibitions on bidder association and collusion	There will be specific rules to prohibit collusion and bidder association.
Limits on acquisition of spectrum and competition issues	We are consulting on the question of whether or not there should be a safeguard cap (e.g. set at 90 MHz) on the amount of spectrum that an eligible bidder can win. We will also consider whether any conditions are required to guard against behaviour such as anti-competitive hoarding.

Question 1: Do you agree with these proposals for the awards of the three bands or have any other comments on the contents of this document?

Next steps

1.32 This consultation closes on 9 March 2007. Ofcom plans to hold a seminar on its proposals in early 2007 for interested parties during the consultation.

1.33 Subject to the outcome of this consultation, Ofcom expects to publish the following key documents during the course of 2007:

a) a statement on this consultation;

b) an Information Memorandum for each of the two proposed awards, describing in detail the relevant information for the awards such as the award procedure and rules, prospective licence conditions and other information likely to affect use of the bands;

c) draft regulations setting out the auction rules with distinct draft statutory instruments for the two separate auctions processes; and

d) draft regulations to allow trading of the proposed licences.

1.34 Ofcom will consider any comments it receives on the draft regulations before finalising them. The regulations will then be made to allow Ofcom to hold the auctions. Before the auctions are held Ofcom expects to hold further "question and answer" seminars for interested parties, in particular on the rules for the auctions.

1.35 As noted above, Ofcom is planning in the near future to embark on consultations in relation to the DDR spectrum and in relation to the liberalisation of spectrum that is currently licensed for 2G and 3G use. In addition, the 2.6 GHz and 2010 MHz bands continue to be the subject of consideration for possible harmonisation within Europe. It is possible that developments in any of these areas could have a bearing on the timing of the awards of the 2.6 GHz and 2010 MHz bands.

1.36 Subject to any material developments in relation to these matters, and subject to the outcome of this consultation, Ofcom considers that it should be possible to proceed with this award in late 2007.

Section 2

Introduction

2.1 This consultation sets out Ofcom's proposals for the award of three distinct spectrum bands: 2500 – 2690 MHz (the "2.6 GHz band"), 2010 – 2025 MHz (the "2010 MHz band") and 2290 – 2300 MHz (the "2290 MHz band").

2.2 The 2.6 GHz band is the most significant piece of spectrum being consulted on in this document because of the amount of spectrum involved (190 MHz) and because of its expected use in other parts of the world for mobile terrestrial services.

2.3 The reason for consulting on the three bands as part of one award programme is that they are potential substitutes for each other or potential complements for a number of candidate applications and they are able to be made available on a similar timescale.

2.4 The document is organised in two main parts.

- The first, which covers sections 2 to 5, sets out the background information of relevance to the award of these bands:

- The second, which covers sections 6 to 9, presents the detail of Ofcom's proposals for the awards and includes the questions on which we are consulting.

2.5 A guide to the contents of each section is given at the end of this introductory section which first provides:

a) the relevant context on Ofcom's spectrum management policies within the framework of which we have developed proposals for these awards;

b) details of previous consultations on these bands;

c) an overview of work that Ofcom has undertaken since these previous consultations as part of the preparation of this consultation document;

d) a description of current uses, and of relevant European harmonisation measures, within the three bands;

e) a summary of the market research carried out on potential future uses identified for the three bands;

f) an overview of other spectrum that may become available for award, or which is currently licensed, which could be used to provide similar services as could be provided using the three bands for award; and

g) a brief comment on the possible timings for the awards.

Background to Ofcom's spectrum management policy

2.6 The proposals outlined in this consultation build upon those in previous consultations and provide detailed information about how Ofcom proposes (subject to the outcome of this consultation) to award wireless telegraphy licences which will permit use of the three available spectrum bands. The consultation aims to provide as comprehensive a description as possible of Ofcom's proposals for the award of wireless telegraphy licences as is possible at this stage and to inform potential bidders of the proposed spectrum packages and auction mechanisms. It also shows how Ofcom proposes to implement its general approach to spectrum management as it applies to these spectrum bands. This general approach has been set out in a number of documents published by Ofcom since the end of 2003, including:

a) the Spectrum Framework Review consultation document published in November 2004 (SFR) and Statement published in June 2005 ("SFR Statement")[10];

b) the Spectrum Trading consultation document published in November 2003 ("Trading Consultation Document") and Statement published in August 2004 ("Trading Statement")[11];

c) the Spectrum Liberalisation consultation document published in September 2004 ("Liberalisation Consultation Document") and Statement published in January 2005 ("Liberalisation Statement")[12]; and

d) the Spectrum Framework Review: Implementation Plan (SFR:IP) and the Interim Statement on the SFR:IP ("SFR:IP Interim Statement") published in January and July 2005 respectively[13].

2.7 The licence awards outlined in this consultation form part of a wider programme of awards that was set out in the SFR:IP and in the Interim Statement on the SFR:IP. Ofcom has so far completed two awards in this programme. In May 2006, it awarded through auction technology neutral licences for the concurrent use of the frequencies 1781.7-1785 MHz paired with 1876.7-1880 MHz. In October 2006, it awarded through auction a technology neutral licence for the use of the frequencies 412-414 MHz paired with 422-424 MHz. Ofcom expects to publish more detailed documents with specific plans for each award as the programme advances. Information on each award project is published and updated as necessary on the section of Ofcom's website dedicated to spectrum awards[14]. In the financial years 2007/08 and 2008/09, Ofcom expects to make a number of other spectrum bands available as part of the programme. In addition to the three bands discussed in this consultation document, the bands due for award include-

a) 1785-1805 MHz (in Northern Ireland);

b) 1452-1492 MHz (L band);

c) frequencies at 10 GHz, 28 GHz, 32 GHz and 40 GHz; and

[10] http://www.ofcom.org.uk/consult/condocs/sfr
[11] http://www.ofcom.org.uk/consult/condocs/spec_trad/statement/
[12] http://www.ofcom.org.uk/consult/condocs/liberalisation
[13] http://www.ofcom.org.uk/consult/condocs/sfrip/
[14] http://www.ofcom.org.uk/radiocomms/spectrumawards/

d) 872-876 MHz paired with 917-921 MHz.

2.8 In the case of 1785-1805 MHz (in Northern Ireland), 10 GHz, 28 GHz, 32 GHz and 40 GHz and 872-876 MHz paired with 917-921 MHz, Ofcom has already published consultation proposals. Subject to consideration of responses, the next steps for each of those projects will include the publication of a statement on the consultation, of an Information Memorandum on the award and of draft regulations for the award process and associated regulatory measures.

2.9 For the other bands listed above, the next step following the SFR:IP will be to publish detailed award proposals for consultation.

2.10 In addition to the spectrum bands discussed in detail in the SFR:IP, specific projects are likely to, or may, result in further spectrum awards. These include the Digital Dividend Review[15] (DDR) and the implementation of the 2005 Cave Audit of public sector spectrum holdings[16]. Ofcom also expects to add spectrum bands to its programme of awards as they become available. To date, since publication of the SFR:IP, Ofcom has invited views on future options for two blocks of up to 4 MHz each in the range 55-68 MHz that are currently largely unused[17].

2.11 Ofcom's general spectrum policy is set out in the SFR Statement:

a) spectrum should be free of technology and usage constraints as far as possible. Policy constraints should only be used where they can be justified;

b) it should be simple and transparent for licence holders to change the ownership and use of spectrum; and

c) rights of spectrum users should be clearly defined and users should feel comfortable that they will not be changed without good cause.

2.12 As described in the SFR Statement, Ofcom's approach to the management of the radio spectrum can be carried out most effectively if market forces are harnessed to a significantly greater degree than in the past. Ofcom considers that this approach will:

- promote more efficient use of the radio spectrum by allowing spectrum to be transferred to, and used by, the user who values it most highly;
- promote competition by increasing the availability of spectrum for use by the most valuable service; and
- facilitate economically valuable innovation as new users enter the market to offer new services.

2.13 The approach is primarily implemented through the development and implementation of three policies:

a) **Spectrum Trading** – allow licensees to buy and sell (and lease and hire) some or all of their spectrum usage rights;

[15] http://www.ofcom.org.uk/radiocomms/ddr/
[16] See the audit's website for more information, at http://www.spectrumaudit.org.uk/, including the final report and the Government's response to the audit.
[17] See http://www.ofcom.org.uk/radiocomms/spectrumawards/awardspending/award_55/.

b) **Spectrum Liberalisation** – give licensees flexibility to change the use they make of the spectrum they hold; and

c) **Spectrum Awards** – make unused spectrum available to potential users as quickly as possible, compatible with an orderly process, on a technology and application neutral basis.

2.14 Ofcom's proposals for the 2.6 GHz, 2010 MHz and 2290 MHz bands are designed to contribute to achieving its objectives within the framework of these policies.

Previous consultation and statements

2.15 In 2003 the Radiocommunications Agency (RA) consulted on the 2.6 GHz band[18]. The purpose of this consultation was to seek views on the approach the UK should adopt in CEPT negotiations for the development of the Electronic Communications Committee of the CEPT (ECC) deliverables relevant to the band. In particular RA consulted on the most appropriate spectrum arrangements and associated issues. Ofcom subsequently issued a short statement[19] which highlighted its view that it should engage actively in the work conducted by CEPT on the 2.6 GHz band at the time, promoting a flexible framework permitting the UK to use market based solutions to decide the optimal use of the spectrum for terrestrial applications. Ofcom took part in discussions in CEPT on that basis. The decisions that resulted from the CEPT work are introduced below and discussed further in section 4.

2.16 In January 2005 Ofcom consulted on the SFR:IP in which it outlined preliminary proposals for the award of the three spectrum bands considered in this consultation. In that consultation Ofcom proposed that the three spectrum bands should be awarded on a technology neutral basis. Ofcom suggested that the 2010 MHz and 2290 MHz[20] bands might be awarded in a single process which would allow the possibility of either pairing parts of the two bands to allow FDD use or for unpaired TDD use. The 2.6 GHz band was proposed as a separate award for a later time. Since the development of the SFR:IP consultation, further work within CEPT has highlighted the possibility of pairing the 2010 MHz band with parts of the 2.6 GHz band (2570 – 2620 MHz). As a consequence several respondents to the SFR:IP suggested that the 2010 MHz band should be awarded in conjunction with the 2.6 GHz band. This suggestion is reflected in our proposals in this consultation.

2.17 In July 2005 Ofcom published the SFR:IP Interim Statement. This set out its intention to move forward with proposals for the award of technology neutral licences for all three of the spectrum bands considered here as soon as practical subject to ongoing negotiations within the CEPT and the EU on harmonisation measures for the 2010 MHz and 2.6 GHz bands.

2.18 On the basis of developments since then, and having undertaken relevant preparatory work, Ofcom considers that it is now appropriate to consult on detailed proposals for the award of the three bands.

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[18] The consultation document is available at http://www.ofcom.org.uk/static/archive/ra/topics/pmc/consult/2-5ghzcondocfinal.doc.

[19] See http://www.ofcom.org.uk/consult/condocs/3g_2500_2690_consultation/.

[20] In the SFR:IP, Ofcom consulted on outline proposals for the band 2290-2302 MHz. As discussed in section 7, after further analysis, Ofcom is proposing to set aside the top 2 MHz, 2300-2302 MHz, for a later award in conjunction with 2302-2310 MHz. The proposals in this document therefore relate to the frequencies 2290-2300 MHz.

Main sources of information and further work used to develop proposals

2.19 Since publication of the SFP:IP Interim Statement Ofcom has commissioned significant further work to prepare this consultation. In parallel, Ofcom has carried out its own work on technical and policy aspects of the proposals and has participated in a range of related European discussions. The proposals in this consultation reflect this work. They also draw on the relevant responses to the SFR:IP consultation and on the responses to the invitation for comments from the European Commission consultation on the 2.6 GHz band.

2.20 Ofcom has commissioned specialist advice on technical issues, on market and economic issues, and on issues relating to the design of the award from independent consultancies Mason Communications Limited (Mason), Analysys Consulting Limited (Analysys) and Dotecon Limited (Dotecon) (altogether the "Consultants").

2.21 Ofcom held a seminar in May 2006[21] so that the Consultants could share with stakeholders their views and invite comments. Ofcom also published on its website contact details for the Consultants so that stakeholders could provide inputs to this work.

2.22 As part of their technical and market research, the Consultants interviewed a number of stakeholders from representative sectors (existing PMSE users; potential operators for mobile telephony, broadband wireless and mobile multimedia services; equipment manufacturers; adjacent users; industry groups and other interested parties). From these interviews, the Consultants made an assessment of the potential uses that might be made of the three bands for award (see paragraphs 2.41 to 2.62 below).

2.23 The Consultants' technical work then considered a detailed assessment of the relevant technical conditions for using candidate technologies in the available bands. Ofcom itself has carried out a substantial amount of complementary analysis of the technical conditions for coexistence of potential services in the available bands with other services operating either in adjacent bands or at the same frequencies. The technical study by Mason and the technical work carried out by Ofcom are being published alongside this consultation document[22].

2.24 The Consultants' economic analysis[23] included modelling of the potential economic value that could be released through use of the spectrum bands. Their analysis indicated that the release of these bands could generate significant benefits to consumers deriving from:

a) new entry into the relevant downstream markets, offering services in competition with the existing operators which could result in price reductions and more consumer choice for services;

b) innovations in relation to new or improved services and applications that operators may be able to offer; and

[21] The slides used for the presentation on 16 May 2006 are available at http://www.ofcom.org.uk/radiocomms/spectrumawards/awardspending/award_2010/mayevent/.
[22] The reports are available at http://www.ofcom.org.uk/consult/condocs/2ghzawards/.
[23] Ofcom considers that publishing the Consultants' economic analysis could influence the commercial behaviour of parties who may be interested in participating in these awards. It could for example influence their views on how much they should be willing to pay for the spectrum. Ofcom considers that it is undesirable for a regulator to influence commercial behaviour in this way, and has therefore decided not to publish this report.

c) cost savings for the existing operators which are likely to be passed on to consumers in the form of price reductions, given the relatively competitive nature of these markets.

2.25 Although estimates of the size of these benefits are uncertain by their nature, the analysis undertaken by the Consultants suggests that the benefits would be substantial.

2.26 The economic analysis also considered in detail the underlying business cases for participation in an award and the potential outcomes to an award process. These results provided an indication of whether entry of new providers of wireless services was likely and whether potential cost savings of existing operators could form the basis of successful bids. Again, such analysis is, by its nature, subject to considerable uncertainty and needs to be treated with caution. However, it is useful in that it provides Ofcom with a context for interpreting the significance of the different expressions of interest in using the bands. For example, the analysis provides insights into the relative demand of prospective bidders for differing amounts of paired and unpaired spectrum in the 2.6 GHz band. In particular, this analysis has indicated that an efficient outcome for the award of the 2.6 GHz band is likely to be best achieved by allowing a flexible approach to the allocation between paired and unpaired spectrum (this is discussed further in section 6 and 7).

2.27 Finally, Dotecon provided specialist auction design advice to identify the most appropriate mechanisms for awarding the available spectrum in accordance with Ofcom's statutory duties.

Current uses and European harmonisation measures

2.28 The three bands for award are either largely unused or already in the process of becoming available for new uses.

2.29 Technical details of existing relevant uses in the three bands and in adjacent bands are provided in section 5 and in the technical study published alongside this consultation document.

2.30 There may also be some non-operational use at present, for research and development purposes, authorised by Ofcom for short periods of time (typically 6 to 12 months) on the basis that the non-operational use will neither cause interference to nor claim protection from other authorised uses.

2.31 International regulatory measures are summarised briefly below and discussed in more detail in section 4, which includes a description of the various international bodies involved in spectrum management.

2500-2690 MHz

2.32 The 2.6 GHz band is currently used for Programme Making and Special Events (PMSE) video applications, such as transmissions using wireless cameras, temporary video links and city-wide video links for electronic news gathering or other programme making. At some frequencies, their use may be airborne, transmitting video data from a helicopter. There are approximately 28 licensees using this band, licensed by JFMG Limited on behalf of Ofcom under contracting out arrangements.

2.33 As a result of the international identification of the 2.6 GHz band for terrestrial mobile services, the PMSE licensees in the band have been notified that their use will cease. Their current licences will expire on 31 December 2006 and from 1 January 2007, PMSE users of the band will hold annual licences revocable on three months' notice. Ofcom expects to decide whether to revoke the PMSE licences or whether to grant further annual licences beyond 31 December 2007 on the basis of when the award of the 2.6 GHz is going to be held. Ofcom expects that any revocation notice would be served so as to take effect by the time of the award.

2.34 The MoD also uses some frequencies within the band at some sites in the UK but will terminate those uses by 31 March 2007.

2.35 Relevant international regulatory measures include the following.

a) Service allocations by the International Telecommunication Union (ITU). The ITU also identified the band on a worldwide basis for terrestrial mobile use by administrations wishing to implement IMT-2000 at its World Radio Conference in 2000. This was because at the time it was anticipated that additional spectrum would be needed for 3G some time in the future over and above that already.

b) Two decisions of the ECC[24] which the UK is not committed to implement.

c) On-going work in the EU's RSC[25], in conjunction with the CEPT and the EU's Communications Committee (COCOM), which could lead to a decision that would be binding on the UK.

2010-2025 MHz

2.36 The 2010 MHz band is currently unused in the UK, as previous plans for licence-exempt self-provided, self-coordinating applications (consistent with CEPT Decisions at the time) did not result in any use.

2.37 Relevant international regulatory measures include:

a) service allocations by the ITU; the ITU also identified the band on a worldwide basis for terrestrial mobile use by administrations wishing to implement IMT-2000 at its World Administrative Radio Conference in 1992 (the 2010 MHz band formed part of the original or 'core' bands identified for 3G in the 2 GHz range at that time);

b) an ECC decision which the UK is not committed to implement; and

c) on-going work in the EU's RSC, in conjunction with CEPT and the EU's COCOM, which could lead to a decision that would be binding on the UK.

2290-2302 MHz

2.38 The 2290 MHz band has been released by MoD and is largely unused except for some remaining MoD use at a military station in Hampshire.

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[24] The European Radiocommunications Office (ERO) is the permanent office supporting the Electronic Communications Committee (ECC). See section 4 for a description of European regulatory bodies. The ERO publishes relevant information from the ECC, including decisions, on its website: http://www.ero.dk/.

[25] See http://europa.eu.int/information_society/policy/radio_spectrum/activities/rsc_work/index_en.htm.

2.39 The band is not the object of any international harmonisation measure relevant to the UK other than under the ITU framework and Ofcom is not aware of any plans for introducing any such measure in Europe.

Ultra Wide Band

2.40 ECC Decision (06)04 on the harmonised conditions for devices using ultra wide band (UWB) technology below 10.6 GHz includes provisions on emissions in the three available bands. As indicated below and described further in section 4, further work on UWB technology is on-going in both CEPT and the RSC.

Potential future uses of the bands

2.41 Ofcom received 68 responses to the SFR:IP. Of those, 32 covered specifically one or more of the bands 2500-2690 MHz, 2010-2025 MHz and 2290-2302 MHz. The responses showed a high level of interest in the three available bands, in particular the 2.6 GHz band.

2.42 In considering potential uses and harmonisation, it is helpful to identify two main categories of technologies that are relevant to the bands:

- paired Frequency Division Duplex (FDD) technologies: and
- unpaired Time Division Duplex (TDD) technologies.

2.43 The significance of these different technologies is that the way they use spectrum requires specific channel arrangements for their efficient coexistence within a given band.

2.44 FDD technologies use two distinct types of frequency block to operate and there generally needs to be a minimum frequency separation (or “duplex spacing”) between the two types of block. Network base stations transmit to user terminals (such as handsets) in particular frequency blocks referred to as *downlink* blocks and user terminals receive on those frequencies. User terminals transmit to network base stations in different frequency blocks referred to as *uplink* blocks and network base stations receive on those frequencies.

2.45 TDD technologies use a single type of frequency block to operate. Network base stations transmit and receive on the same frequency. Similarly, user terminals transmit and receive in the same frequency blocks as the network base stations. The ability to use the same frequency for transmit and receive is achieved by placing these signals in different time slots (essentially, a burst of downlink is followed by a burst of uplink).

2.46 The market research conducted by Analysys and Mason identified four main categories of services that could be delivered using the three bands.

a) Advanced mobile telephony services using 3G technologies and their evolutions (UMTS FDD, HSPA and Long Term Evolution) which are optimised for a mix of voice and data traffic. These would allow the further development of mobile telephony and data services currently available in the UK.

b) Broadband wireless services using WiMAX standards (2005/revision e in particular) or a variant of the 3G family (UMTS TDD) which are optimised for carrying data with VoIP calls as one data application. These would allow the delivery of high data rate services to fixed, nomadic or mobile devices. Some of the relevant technologies, including WiMAX revision e, are not in use in the UK at present. As the major new frequency band identified internationally for mobile communications since 2000, the 2.6 GHz band is generally the main spectrum band targeted for operation of these new technologies.

c) Mobile multimedia services that could complement cellular or broadband wireless services or be stand-alone services. Using specific additional applications based on MBMS or TDtv for example, services like mobile television could be delivered to cellular or broadband wireless terminals. A service could also be delivered using technologies such as DVB-H or DMB. Any of these technologies could potentially allow the delivery of broadcast content to portable multimedia devices.

d) PMSE services, primarily for digital video applications (e.g. wireless cameras, temporary links, mobile or portable links), enabling such activities as news coverage and the broadcasting of planned events, for example concerts or football games.

2.47 The above list refers to the technologies that were identified by the Consultants as the most likely to be deployed in the three bands. Annex 7 provides a fuller list of technologies that may be used. All technologies identified in the Annex are such that their channel rasters:

a) either occupy a bandwidth of 5 MHz or integer multiples of 5 MHz (10 MHz, 20 MHz); or

b) are such that several channels fit efficiently within a 5 MHz block (e.g. in a 5 MHz block, 4 channels of 1.25 MHz for Flash OFDM or 8 channels of 625 kHz for HC-SDMA).

2.48 This characteristic of their channel raster is relevant to the proposed size for the lots discussed in relation to the packaging of the spectrum (see section 7).

2.49 The evidence of strong interest in use of the bands that comes out of the market research reinforces one of the main messages that came out of the SFR:IP responses, namely that the bands are likely to enable use of new and innovative technologies. It is expected that these could allow the development of existing, and the introduction of new, mobile voice, data and multimedia services.

2500-2690 MHz

2.50 Respondents to the SFR:IP consultation, including existing Mobile Network Operators (MNOs), equipment manufacturers, wireless operators and industry groups, suggested that the 2.6 GHz band was appropriate for use of a wide range of technologies. Two main categories of candidate technologies emerged from the responses, with respondents signalling strong interests in both.

2.51 The first category of responses expressed support for specific 3G technologies, arguing that the spectrum should be specifically reserved for them. Some, including MNOs and the UMTS Forum, claimed that the 2.6 GHz band should be reserved for mobile telephony services using UMTS and potentially other technologies in the IMT-2000 family. Some were also specific in arguing in favour of conforming to the harmonisation measures of ECC Decision (05)05, with fixed frequencies for FDD use (2x70 MHz) and for TDD use (50 MHz). The respondents suggested that the spectrum would be used to provide mobile telephony and data services similar to those provided using the core 3G spectrum bands at 1920-1980 MHz paired with 2110-2170 MHz.

2.52 The second category of responses was based on support for flexibility in the use of the 2.6 GHz band or use of technologies other than IMT-2000/UMTS. A large number of stakeholders – including operators BT and Pipex, equipment manufacturers Nortel and Lucent, industry groups IEEE 802 and Intellect – supported technology neutrality. Some of those were more specific and suggested that TDD technologies, including WiMAX, were particularly suitable for delivery of wireless broadband services and potentially innovative services. The Digital TV Group also identified a potential for broadcast applications and DVB-H for mobile television.

2.53 These responses are consistent with the main types of uses and technologies that have been identified by the Consultants as part of their market analysis. The SFR:IP responses and the Consultants' work both suggest that, at a high level, there are two main types of technologies that could be used in the 2.6 GHz band, paired FDD technologies and unpaired TDD or broadcast technologies. They also point to the high potential demand for spectrum within the 2.6 GHz band for all these technologies.

2.54 Ofcom recognises that uses or plans for use of the 2.6 GHz band internationally reflect those two main types of uses. In Europe, EU and CEPT members have been considering how the band should be made available; FDD using IMT-2000/UMTS and TDD using WiMAX or UMTS TDD are amongst the main technologies on which discussions have focussed. In the USA, the band is for a large part available for wireless broadband systems and the operators Clearwire and Sprint Nextel signalled in July and August 2006 their plans to develop networks in the spectrum using WiMAX technology. In Japan, at least part of the band is under consideration for mobile telephony services (FDD, IMT-2000) and broadband wireless services (TDD, WiMAX).

2.55 PMSE use was not specifically identified by respondents to the SFR:IP for the 2.6 GHz band. However, the band is suitable for those applications (it is the current use). The Consultants confirmed that PMSE was a potential use but were of the view that prospective PMSE users might not participate very actively in a competitive award process for the 2.6 GHz band as they might place significantly lower value on the spectrum than other potential users.

2010-2025 MHz and 2290-2302 MHz

2.56 Information obtained on potential uses of the 2010 MHz and 2290 MHz bands shows that they are similar for both bands.

2.57 SFR:IP respondents largely supported technology neutrality for both bands, although some MNOs considered that the 2010 MHz band should be reserved for IMT-2000/UMTS technologies and FMS solutions encouraged Ofcom to consider whether the 2010 MHz band should assigned for 3G services.

2.58 BT considered that broadband wireless technologies other than IMT-2000 might be used; Broadband Access Strategies saw the 2010 MHz band as a real opportunity for WiMAX in Europe; the BBC and Channel 4 submitted that both bands could be used for wireless cameras and PMSE; the Digital TV Group considered that the band could be suitable for use of DVB-H.

2.59 In response to the SFR:IP consultation question of whether it would be desirable to allow pairing of the two bands for FDD use, a small number of respondents suggested that the option should not be precluded. However, it was not clear that there were any particular plans to deliver services using FDD technologies in those bands. The interest in linking the bands seemed to reside more in allowing combined use for TDD, providing greater bandwidth across the two.

2.60 Furthermore, the research carried out by the Consultants, which has been conducted after the adoption of the two relevant ECC decisions[26], has identified little or no interest in pairing. On the basis of the evidence they gathered, the Consultants did not consider pairing either 2010-2025 MHz with part of 2570-2620 MHz or 2010-2025 MHz with 2290-2302 MHz for FDD use as attractive options. The issue of pairings between the three bands is discussed further in section 8 on auction design.

2.61 As a result, the Consultants considered broadband wireless using TDD technologies and PMSE as the main potential uses for the two bands. More specifically, they suggested that PMSE was likely to be the main candidate use of the 2290 MHz band while broadband wireless or potentially broadcast technologies (e.g. MBMS) and PMSE were more likely for the 2010 MHz band.

2.62 The Consultants' analysis also confirmed the proposition that interest in the 2010 MHz band is greater than in the 2290 MHz band, due to its availability across Europe and the scope for the introduction of similar services in a number of countries.

Related spectrum

2.63 There are alternative spectrum bands that could be used to provide similar services to the services that might be provided in the three bands for award. Some of those bands are already assigned; others may become available in the future through release by Ofcom to the market. However, the characteristics of these other bands differ in varying respects from the three bands covered in this consultation.

2.64 Bands that may be awarded in future include frequencies in the band 470-862 MHz (UHF bands IV and V); 1452-1492 MHz (L band), 1785-1805 MHz (available in Northern Ireland), 2302-2310 MHz, 1790-1798 MHz (in Great Britain) or spectrum at 3.6 GHz. These bands were identified as part of Ofcom's programme of spectrum awards in the SFR:IP in January 2005. Further information on Ofcom's programme of spectrum awards can be found on the Ofcom website[27].

2.65 Significant amounts of spectrum are likely to become available, nationally or locally, in the band 470-862 MHz, as a result of the planned switchover to digital terrestrial television and of Ofcom's review of the band (a project called the Digital Dividend Review[28]). As part of its initial analysis, Ofcom identified a number of potential uses for the band, some of which are also relevant to the 2.6 GHz band. Ofcom has held various events with stakeholders to set out its approach to, and the scope of, work it commissioned the Consultants. It also held a briefing following the conclusion of the Regional Radiocommunications Conference 2006[29], to provide information about the implications of the conference for the band in the UK. Ofcom now expects to publish

[26] ECC Decision (05)05 and ECC Decision (06)01 which refer to the possibility of pairing 2010-2025 MHz with part of the centre block of the 2.6 GHz band at 2570-2620 MHz.
[27] See http://www.ofcom.org.uk/radiocomms/spectrumawards/.
[28] For further information on the DDR, see http://www.ofcom.org.uk/radiocomms/ddr/.
[29] Slides used during the presentation are available on Ofcom's website at http://www.ofcom.org.uk/media/speeches/2006/06/rrc2006.

around the end of 2006 a consultation document on the options for the award of the spectrum that is likely to become available in the band 470-862 MHz. The spectrum released as a result of the digital switchover process would only become available nationally in line with the digital switchover plan which is in 2012 at the earliest. However an award of licences for use of the released spectrum could take place earlier.

2.66 In March 2006, Ofcom published a consultation document on award proposals for the band 1452-1492 MHz[30]. Potential uses include mobile multimedia and broadcast services including radio broadcasting using T-DAB. Work has been carried out, and further work is continuing, on international arrangements relating to the use of these frequencies. On 17 October 2006, Ofcom published an update[31] on the international developments relevant to the award and an update on the planned next steps for the project. These are currently planned to include publications on auction design and technical aspects of the award before the end of 2006. Ofcom's aim is to conduct an award of the band in the second half of 2007, although this timing may change depending on the outcome of the international processes.

2.67 In December 2005, Ofcom published a consultation document[32], jointly with ComReg, the Irish regulator, setting out detailed proposals for the award of the band 1785-1805 MHz which is available in both Northern Ireland and the Republic of Ireland. Following further technical analysis, Ofcom published an update in October 2006[33] including revised proposals for the spectrum masks for transmission under the proposed licence. Ofcom expects to publish a statement on the consultation, an Information Memorandum for the award and draft regulations by the end of 2006. The award could then be held during the first half of 2007.

2.68 The SFR:IP also included a brief discussion of a potential award of the band 2302-2310 MHz. As discussed in section 5 of this document, it is proposed to reserve the frequency block 2300-2302 MHz previously considered as part of the 2290-2302 MHz band for an award of 10 MHz at 2300-2310 MHz. Although Ofcom has not carried out any detailed research at this stage, it seems likely that this spectrum could be used for PMSE and potentially broadband wireless services, as it is within the range of WiMAX in the band 2300-2400 MHz. Work is still required to determine with current users what migration plan should apply. Ofcom expects that it could be in a position to publish a consultation document on award proposals for the 2300-2310 MHz band in 2007/08.

2.69 There may also be other spectrum bands that could become available as a result of the programme of work that is following on from the Independent Audit of Spectrum Holdings, which was concluded in December 2005[34]. The Government responded to the audit, accepting its recommendations and committing to an implementation plan that is likely to lead to spectrum releases in the coming years[35]. Government departments are expected to identify key bands that it may be possible to make available to third parties and to outline specific proposals for actions in these bands. These proposals will be outlined in a Government "forward look" document expected to be published in spring 2007 and an update was published on 6 December[36].

[30] http://www.ofcom.org.uk/consult/condocs/1452-1492/
[31] http://www.ofcom.org.uk/radiocomms/spectrumawards/awardspending/award_1452/intupdate/
[32] See http://www.ofcom.org.uk/consult/condocs/availspec/.
[33] See http://www.ofcom.org.uk/radiocomms/spectrumawards/awardspending/award_1785/update/.
[34] The report is available at http://www.spectrumaudit.org.uk/final.htm.
[35] The Government's response is available at http://www.spectrumaudit.org.uk/220306.htm.
[36] See http://www.spectrumaudit.org.uk/news.htm.

2.70 There are also other spectrum bands that are currently licensed and in use which may be suitable for the provision of services that could also be provided using the 2.6 GHz, 2010 MHz and 2290 MHz bands. Some examples of such bands include:

a) the 900 MHz (880-915 MHz paired with 925-960 MHz) and 1800 MHz (1710-1785 MHz paired with 1805-1880 MHz) bands currently licensed for GSM technology (also referred to as 2G) and being considered in international fora for other technologies such as UMTS/IMT-2000;

b) the 2.1 GHz band (1920-1980 MHz paired with 2110-2170 MHz and 1900-1920 MHz) currently licensed for UMTS technology (also referred to as 3G and part of the IMT-2000 family);

c) spectrum in the 3.4 GHz band (3480-3500 MHz paired with 3580-3600 MHz) currently licensed for fixed wireless access (provision of wireless services at fixed locations) and the 3.6 GHz band (3605-3689 MHz paired with 3925-4009 MHz) licensed for fixed wireless access as well and shared with satellite services; and

d) the 450-470 MHz band, currently licensed for various business radio uses (private communications services for businesses).

2.71 The relationship between the 2.6 GHz, 2010 MHz and 2290 MHz bands and bands referred to above, in particular the 2G spectrum at 900 MHz and 1800 MHz and 3G spectrum at 2.1 GHz, is discussed further in section 6.

2.72 It is also possible that spectrum that is currently assigned may, in future, be returned to Ofcom, for example if a licensee ceases its commercial activities or if it decides to return to Ofcom part of the frequencies it had been using. In such a case, Ofcom would expect to award the frequencies in line with its general policy for spectrum releases, as described in the SFR:IP and SFR:IP Interim Statement, taking account of the relevant circumstances at the time.

2.73 Other spectrum may also become suitable for related or similar uses as a result of technological developments, for example enabling the use of higher frequencies which are currently unused or underused. This possibility has been illustrated by Ofcom's decision in relation to the licensing of the bands 71-76 GHz and 81-86 GHz[37].

2.74 Spectrum currently assigned to one party may also become available to be assigned to other interested parties without an award process being held by Ofcom when rights and obligations for its use can be traded by the current holders. Spectrum bands where trading is possible are identified in the UK Plan for Frequency Authorisation[38].

Timing of the awards

2.75 The questions of whether and when it would be appropriate to hold the awards are considered in detail later in this document. Section 6 presents an analysis which suggests that it would be desirable to hold the awards as soon as practicable. Ofcom considers that the earliest that this would be feasible is in late 2007. As explained in

[37] See the statement published on 8 November 2006, available at http://www.ofcom.org.uk/consult/condocs/71-86ghz/statement/.

[38] See the Wireless Telegraphy (Spectrum Trading) Regulations 2004 (Statutory Instrument 2004 No. 3154) as amended for the provisions relevant to spectrum trading and http://www.ofcom.org.uk/radiocomms/isu/ukpfa/intro for the UK Plan for Frequency Authorisation.

section 6, however, there are a number of considerations that could cause the awards to be delayed beyond 2007.

2.76 This consultation also considers whether the three bands should be awarded under the same process or under distinct processes and, in the latter case, whether the awards should take place at the same or different times. This is discussed further in section 8. However, even if two or three distinct award processes were to take place, Ofcom expects that these would take place within a relatively short period of time, probably within a few weeks or months of each other.

Matters covered in this document

2.77 The purpose of this document is to provide a detailed description of Ofcom's proposals for the award of the 2.6 GHz, 2010 MHz and 2290 MHz bands. It falls logically into a number of parts.

2.78 The first part provides a background to the award proposals and consists of:

- Section 2 – this Introduction;
- Section 3 – which provides a summary of Ofcom's functions and duties in so far as these are relevant to this award;
- Section 4 – which describes various international issues relevant to the spectrum available for award, including the international spectrum allocation tables, existing European regulatory decisions that relate to these bands and potential future EU provisions that could effect these bands; and
- Section 5 – which provides a summary of allocations and uses, both within the bands themselves and in adjacent spectrum, and considers the impact that these may have on the technical conditions under which the three bands can be made available for award.

2.79 The second part provides details of Ofcom's proposals for the awards and sets out a number of questions on which we are consulting. It consists of the following.

- Section 6 – which addresses a number of high level issues that will determine the overall approach to the awards. It opens with a summary of Ofcom's objectives for the awards and then considers a series of questions relating to authorisation including: the question of whether Ofcom should proceed to authorise the use of the three bands; the choice of authorisation mechanism; and possible future authorisation decisions that may become relevant to these bands. The section then goes on to consider a range of issues relating to: the timing of the awards, flexibility in access by different types of technologies, non-technical licence conditions and competition related issues.
- Section 7 – which considers that way in which spectrum within each of the three bands should be packaged for award, taking account of the work on technical constraints and on likely uses of the bands.
- Section 8 – which addresses the questions of auction design and the associated rules. This section begins with a summary of some key practical concerns that influence auction design. It then considers the potential linkages between the three bands and sets out proposals for grouping and sequencing the award of the three bands. Following a description of the main choices of auction format,

section 8 then considers the choice of detailed auction format for the 2.6 GHz and 2010 MHz bands and for the 2290 MHz band.

- Section 9 – which describes the specific technical conditions that will apply to the licences, with these conditions being specified in two alternate forms, the first using transmitter spectrum masks and the second using spectrum usage rights. This section also covers other coordination and interference management issues.

2.80 Section 10 sets out the next steps leading up to the awards.

2.81 Annexes 1 to 3 set out further information about Ofcom's consultation principles and the process for responding to this consultation.

2.82 Annex 4 provides a list of the consultation questions.

2.83 Other Annexes provide further background information relevant to the award.

- Annex 5 sets out an impact assessment in accordance with Ofcom's statutory requirement.
- Annex 6 sets out a summary of relevant responses to the SFR:IP.
- Annex 7 provides a list of technologies identified for potential use in the three available bands and their technical spectrum requirements.
- Annex 8 provides further detail on the proposed auction formats.
- Annex 9 contains a draft licence for information purposes, which illustrates the format of the licence which will be offered.
- Annex 10 provides a brief summary of other regulation relating to electronic communications networks and services and broadcasting which may be relevant to potential licensees.
- Annex 11, 12 and 13 provide further details on the implementation of the concept of spectrum usage rights (SURs) which Ofcom has put forward in 2006 as a way to define flexible rights to transmit for spectrum licences.
- Annex 14 provides a glossary of key terms.

2.84 In addition, Ofcom is publishing two technical studies which underpin the analysis in this consultation document:

- a technical report prepared by Mason Communications Ltd; and
- a technical report prepared by Ofcom.

2.85 Both reports are available on the Ofcom website at http://www.ofcom.org.uk/consult/condocs/2ghzawards/.

Section 3

Ofcom's functions and duties

3.1 This section provides a brief overview of the main UK and European legislative provisions relevant to wireless telegraphy licensing and to the proposed award process. It does not provide a comprehensive statement of all the legal provisions which may be relevant to Ofcom's functions and to the award of wireless telegraphy licences for the use of the 2.6 GHz band, the 2010 MHz band and the 2290 MHz band. Other relevant regulatory provisions are also briefly summarised at Annex 10.

3.2 Interested parties should seek their own legal advice in relation to legal provisions that are relevant to the available spectrum bands and potential plans they may have for their use.

3.3 For the avoidance of doubt, references in this consultation to Wireless Telegraphy Acts are to the Wireless Telegraphy Acts that are in force at the time of publication. The Wireless Telegraphy Act 2006 was passed by Parliament on 25 October 2006. It received Royal Assent on 8 November 2006 and will come into force in the UK in February 2007. The new Act replaces the Wireless Telegraphy Acts 1949, 1967 and 1998, the Marine etc Broadcasting (Offences) Act 1967, Part 6 of the Telecommunications Act 1984 and certain provisions of the Communications Act 2003[39].

Ofcom's general duties

3.4 Under section 3(1) of the Communications Act 2003 (the "2003 Act") it is the principal duty of Ofcom in carrying out its functions:

(a) to further the interests of citizens in relation to communications matters; and

(b) to further the interests of consumers in relevant markets, where appropriate by promoting competition.

In doing so, Ofcom is required to secure (under section 3(2)):

(a) the optimal use for wireless telegraphy of the electro-magnetic spectrum;

(b) the availability throughout the UK of a wide range of electronic communications services;

(c) the availability throughout the UK of a wide range of TV and radio services which (taken as a whole) are both of high quality and calculated to appeal to a variety of tastes and interests;

(d) the maintenance of a sufficient plurality of providers of different television and radio services;

[39] Acts of Parliament can be found at http://www.opsi.gov.uk/acts.htm. As soon as the Wireless Telegraphy Act 2006 comes into force, the references in this document to the various Acts that will be replaced should be deemed to be updated by the Wireless Telegraphy Act 2006.

(e) the application in the case of all television and radio services of standards that provide adequate protection to members of the public from the inclusion of offensive and harmful material, unfair treatment in programmes and unwarranted infringement of privacy;

and to have regard to certain matters which include:

- principles of better regulation (section 3(3));
- the desirability of promoting competition (section 3(4));
- the desirability of encouraging investment and innovation (section 3(4)(d));
- the desirability of encouraging availability and use of broadband services throughout the UK (section 3(4)(e)); and
- the different needs and interests of persons in different parts of the UK (section 3(4)).

3.5 As the management of the UK radio spectrum is governed by the European Communications Directives, which aim to harmonise the regulation of electronic communications networks and services throughout the European Union, section 4 of the 2003 Act requires Ofcom when carrying out its spectrum functions to act in accordance with the "six Community requirements" set out in that section when managing the wireless spectrum in the UK. Of relevance are the following:

(a) the requirement to promote competition (section 4(3));

(b) the requirement to secure that Ofcom's activities contribute to the development of the European internal market (section 4(4));

(c) the requirement to promote the interests of all persons who are citizens of the European Union (section 4(5));

(d) the requirement to act in a technology neutral way (section 4(6));

(e) the requirement to encourage to such extent as appropriate the provision of network access and service interoperability (section 4(7)); and

(f) the requirement to encourage such compliance with international standards as is necessary for: (a) facilitating service interoperability; and (b) securing freedom of choice for the customers of communications providers (sections 4(9) and (10)).

Ofcom's duties when carrying out spectrum functions

3.6 In carrying out its spectrum functions it is the duty of Ofcom (under section 154 of the 2003 Act) to have regard in particular to:

(a) the extent to which the electro-magnetic spectrum is available for use, or further use, for wireless telegraphy;

(b) the demand for use of that spectrum for wireless telegraphy; and

(c) the demand that is likely to arise in future for the use of that spectrum for wireless telegraphy.

It is also the duty of Ofcom to have regard, in particular, to the desirability of promoting:

(a) the efficient management and use of the spectrum for wireless telegraphy;

(b) the economic and other benefits that may arise from the use of wireless telegraphy;

(c) the development of innovative services; and

(d) competition in the provision of electronic communications services.

3.7 Where it appears to Ofcom that any of its duties in section 154 conflict with one or more of its general duties under sections 3 to 6 of the 2003 Act, priority must be given to its duties under those sections 3 to 6.

Granting wireless telegraphy licences

3.8 Ofcom's legal power to grant wireless telegraphy licences is set out in the Wireless Telegraphy Act of 1949 (the "1949 Act"). Section 1(1) of the 1949 Act makes it an offence for any person to establish or use any station for wireless telegraphy or to install or use any apparatus for wireless telegraphy except under and in accordance with a licence granted by Ofcom under that section (a wireless telegraphy licence).

3.9 Section 1(2) of the 1949 Act gives Ofcom the power to grant wireless telegraphy licences subject to such terms as Ofcom thinks fit.

3.10 However, Ofcom's broad discretion in relation to the terms that can be imposed in a wireless telegraphy licence is subject to the rule that Ofcom must impose only those terms that it is satisfied are objectively justifiable in relation to the networks and services to which they relate, not unduly discriminatory, and proportionate and transparent as to what they are intended to achieve (section 1D(9)).

Providing for an auction of wireless telegraphy licences

3.11 Under Article 5(2) of the Directive on the authorisation of electronic communications networks and services 2002/20/EC (the "Authorisation Directive"), when granting rights of use of radio frequencies (wireless telegraphy licences in the UK context), Member States must do so through open, transparent and non-discriminatory procedures.

3.12 Under Article 7(3) of the Authorisation Directive where the number of rights of use of radio frequencies needs to be limited, Member States' selection criteria must be objective, transparent, non-discriminatory and proportionate. (Section 164 of the 2003 Act requires Ofcom to make an order setting out the criteria.)

3.13 Within that context, Ofcom has power under section 3 of the Wireless Telegraphy Act 1998 (the "1998 Act") (having regard to the desirability of promoting the optimal use of the electro-magnetic spectrum) to make regulations providing that applications for the grant of wireless telegraphy licences must be made in accordance with a procedure which involves the applicants making bids for licences (for example an auction).

3.14 Ofcom has broad powers in section 3(3) of the 1998 Act to make provision in regulations for the form of the licences and the auction bidding procedure.

Charging fees for wireless telegraphy licences

3.15 Ofcom also has power, under section 1 of the 1998 Act, to prescribe in regulations fees that are payable in respect of wireless telegraphy licences or a grant of spectrum access. Under section 2 Ofcom may prescribe sums which are greater than necessary for the purpose of recovering costs incurred in connection with functions relating to the management of the radio spectrum, if it thinks fit in the light (in particular) of the matters to which they are required to have regard under section 154 of the 2003 Act.

3.16 The fees for most wireless telegraphy licences are set out in such specific regulations (including those fees which are set by Ofcom in order to incentivise the efficient use of the spectrum). The current regulations are the Wireless Telegraphy (Licence Charges) Regulations 2005 (SI 2005/1378).

3.17 Under Article 13 of the Authorisation Directive, any fees imposed for rights of use of radio frequencies shall reflect the need to ensure the optimal use of the resources. Such fees must be objectively justifiable, transparent, non-discriminatory and proportionate in relation to their intended purpose (and take into account the objectives set out in Article 8 (Policy objectives and regulatory principles) of the Directive on a common framework for electronic communications networks and services 2002/21/EC (the “Framework Directive”).

Potential changes to the regulatory framework

3.18 The Authorisation Directive and the Framework Directive are part of the EU regulatory framework for electronic communications networks and services of 2002[40]. The framework anticipated a regular review, every three years, to ensure that it keeps pace with technological and market developments. The European Commission is presently undertaking the first review of the legal instruments that make up this framework[41].

3.19 Preliminary work started at the end of November 2005 with a Call for Input enabling stakeholders to give their views on the application and functioning of the framework and possible changes to it[42].

3.20 Following the Call for Input and associated consultation, the European Commission issued a Communication on the Review of the EU regulatory framework for electronic

[40] This includes Framework Directive 2002/21/EC, Authorisation Directive 2002/20/EC, Access Directive 2002/19/EC, Universal Service Directive 2002/22/EC, Directive on Privacy and Electronic Communications 2002/58/EC.

[41] http://europa.eu.int/information_society/policy/ecomm/tomorrow/index_en.htm

[42] http://europa.eu.int/information_society/policy/ecomm/doc/info_centre/public_consult/review/comments/511_25_call_for_input_comp.pdf

communications networks and services on 29 June 2006[43]. This Communication launched a public consultation on the future of the electronic communications regulatory framework. The period to provide comments ended on 27 October 2006. The Communication was complemented by a Staff Working Document, which outlined in greater detail the proposed changes to the regulatory framework[44], and an Impact Assessment[45] which described the options considered for the review and provided background for the proposed changes. These documents include proposals for changes to spectrum management and changes that are relevant to services provided through wireless networks (e.g. roaming).

3.21 On 29 June 2006, the European Commission also launched a Public Consultation on a draft Commission Recommendation on relevant product and service markets within the electronic communications sector susceptible to ex ante regulation in accordance with the Framework Directive and its associated explanatory memorandum[46]. This included proposals for the inclusion of a wholesale market for SMS and mobile call termination and consideration of whether the market for wholesale mobile call origination and access should be removed.

3.22 The Commission Communication and revised recommendation marked the last preparatory step of the 2006 Review process, before the publication of the proposals for revision of the Directives comprising two amending Directives: one covering the Framework, Authorisation and Access and Interconnection Directives; and the other covering the Universal Service and Privacy Directives. The Commission expects to publish the draft amending Directives in early 2007. Subject to relevant legislative processes, the revised framework could be in force by 2009 with implementation by Member States during the course of 2009 and 2010.

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43 http://europa.eu.int/information_society/policy/ecomm/doc/info_centre/public_consult/review/com334_en.pdf

44 http://europa.eu.int/information_society/policy/ecomm/doc/info_centre/public_consult/review/recommendation_final.pdf

45 http://europa.eu.int/information_society/policy/ecomm/doc/info_centre/public_consult/review/impactassessment_final.pdf

46 http://europa.eu.int/information_society/policy/ecomm/doc/info_centre/public_consult/review/recommendation_final.pdf

Section 4

International provisions

4.1 This section sets out a summary of the international regulatory provisions which impact on the potential future uses of the 2.6 GHz, 2010 MHz and 2290 MHz bands in the UK. These provisions include-

a) the international allocations of spectrum to different radiocommunications services as decided by the ITU, which identify the main potential types of services internationally and are relevant to the prevention and resolution of interference issues between countries;

b) existing European measures of the CEPT which refer specifically to these bands, notably the CEPT band plan for the 2.6 GHz band. These provide a point of reference for the design of awards in UK although it should be noted that the UK can choose to, but is not required to, implement CEPT decisions in this regard; and

c) current European work on possible future harmonisation measures that affect these bands, in particular on-going work by the RSC, a regulatory committee of the EU that can adopt decisions which are binding on member states, and by CEPT on behalf of the European Commission (EC).

4.2 To provide appropriate context this section begins with a brief description of ITU, CEPT and EU regulatory groups, since the way that these international regulatory institutions operate is important in understanding the nature of the international provisions that affect spectrum use.

International regulatory institutions for spectrum management

4.3 The UK is one of 191 members of the ITU[47]. The ITU has certain international responsibilities which include allocating bands of the radio frequency spectrum, allotting radio frequencies and registering radio frequency assignments. It is an international treaty organisation which deals with its members and their national administrations, such as Ofcom in the UK. The ITU also organises a major conference which takes place every 3 years, the World Radio Conference, at which these arrangements are reviewed.

4.4 The CEPT[48] is a forum for regulatory authorities from its 47 member states to cooperate in addressing international issues relating to postal and electronic communications matters in Eastern and Central Europe, working with industry and other interested parties as appropriate. All 25 EU member states are members of the CEPT.

[47] See http://www.itu.int/.
[48] See http://www.cept.org/.

4.5 Within the CEPT, the Electronic Communications Committee (ECC)[49] is responsible for matters relating to electronic communications including spectrum management. The ECC's main activities and responsibilities in relation to spectrum include:

a) developing common European proposals for input to periodic reviews of ITU provisions;

b) preparing reports on the technical analysis of spectrum use in specific circumstances (e.g. compatibility between use of different technologies at adjacent frequencies or at shared frequencies);

c) preparing recommendations on options for addressing specific technical and regulatory issues; and

d) preparing and adopting decisions on the harmonisation of spectrum use.

4.6 CEPT member states can decide, but are not required, to commit to the implementation of ECC decisions.

4.7 The CEPT and the ECC work closely with the EC and its relevant groups on some spectrum matters, as described at paragraph 4.9 below.

4.8 The EU's Radio Spectrum Committee (RSC) is the group responsible for adopting regulatory decisions on spectrum use at EU level.

4.9 The Radio Spectrum Decision[50] establishes procedures for policy making and policy implementation in the field of spectrum management in the EU. The Radio Spectrum Decision specifies that the activities of the EC and the RSC that are pursued under the Decision must take due account of the work of international organisations related to radio spectrum management, e.g. the ITU and the CEPT. The Radio Spectrum Decision also identifies CEPT's role under mandates from the EC in providing input to the RSC's work on technical implementing measures. Subject to approval by representatives of the EU member states according to specific provisions, the EC can decide to make a decision on the basis of CEPT's response to a mandate. Such a decision can be binding on all member states and can include a specific deadline for its implementation.

4.10 The RSC also regularly interacts with other EU groups as necessary, such as:

a) the Radio Spectrum Policy Group (RSPG), which has an advisory role[51] to assist in determining long term strategies for spectrum management; and

b) the Communications Committee (COCOM), which is a regulatory group of the EU responsible for issues related to authorisation matters, not restricted to technical conditions of access to spectrum, and has an advisory and regulatory role[52] in relation to electronic communication services and networks.

[49] See http://www.ero.dk/.
[50] Decision No. 676/2002/EC of the European Parliament and of the Council of 7 March 2002 on a regulatory framework for radio spectrum policy in the European Community.
[51] The RSPG was established under Commission Decision 2002/622/EC of 26 July 2002.
[52] The COCOM was established under the Framework Directive (see article 22).

International spectrum allocations

4.11 Both ITU and CEPT have developed spectrum allocation frameworks which define which uses have recognition within each frequency band. These are important because they have a bearing on:

- which services will be able or likely to make use of the 2.6 GHz, 2010 MHz and 2290 MHz bands following an award in the UK; and

- what other uses these services might need to coexist with, both in terms of uses in immediately adjacent bands and also in terms of uses in neighbouring countries. The implications of these other uses for the technical constraints on the way that the available spectrum can be offered for award in the UK are examined in section 5.

4.12 The relevant allocations by ITU and CEPT within each of the three relevant bands are summarised below. Not surprisingly, the market research carried out into potential uses of the 2.6 GHz, 2010 MHz and 2290 MHz bands (see paragraph 2.46) identified services which are compatible with the ITU allocations in the Radio Regulations (ITU RRs).

<u>ITU Radio Regulations</u>

4.13 The ITU is a specialised agency within the United Nations system of organisations. The ITU's Constitution, Convention and Administrative Regulations (of which the ITU RRs are a part) together form an international treaty governing the use of the radio spectrum to which the 191 signatory ITU Member States (of which UK is one) are bound. Member States are each represented by their national administration, which is the government department or service responsible for discharging the obligations set out in these instruments and adopting appropriate national legislation to implement these obligations.

4.14 The ITU RRs define those uses for specific spectrum bands that will have international recognition in each of the three ITU regions. Within each frequency band, radio communications services are allocated on the basis of 'primary' and 'secondary' services, either on a worldwide or regional basis. By definition, stations of a secondary service shall neither cause interference to, nor claim protection from harmful interference caused from, existing or future stations of the primary service. In many instances, bands of frequencies are allocated to more than one service on a co-primary basis. In such cases, specific sharing conditions are imposed on each service e.g. limitations on transmitter power (effective isotropic radiated power (EIRP)), minimum elevation angles for earth stations and maximum levels of interference.

4.15 The purpose of submitting data to the ITU is so that the frequency assignments to which the data relate can be registered in the ITU Master International Frequency Register (the 'Master Register') and so receive international recognition in accordance with Article 8 of the ITU RRs. The international rights and obligations of administrations in respect of their own and other administrations' frequency assignments are derived from the recording of the assignments in the Master Register, or the conformity of the assignments with a frequency plan.

4.16 If an operator is awarded a licence by a national administration for a service that does not fall within the ITU RRs, that assignment will have no status under the ITU RRs and thus no international recognition. This does not mean that the service may not be authorised nationally, or that it may not be provided, but that it will have no rights to protection from interference caused by a service consistent with ITU allocations in another member state of the ITU. If the service that is operating outwith the ITU RRs causes interference to an assignment in another country that is operating in accordance with the ITU RRs, the former station may have to be shut down (even if the assignment in the other country was not registered in the ITU Master Register at the time of the initial operation).

4.17 In region 1 of the ITU, which includes Europe, the three bands have the following allocations (see also Figures 4, 5 and 6 in section 5).

i) 2.6 GHz band

- co-primary allocation to the fixed and mobile (except aeronautical mobile) services at 2500-2690 MHz;
- co-primary allocation to the mobile-satellite service at 2500-2520 MHz and at 2670-2690 MHz;
- co-primary allocation to the broadcasting satellite service at 2520-2670 MHz; and
- secondary allocations to the earth exploration satellite (passive), radio astronomy and space research (passive) services at 2655-2690 MHz.

ii) 2010 MHz band

- co-primary allocation to the fixed and mobile services.

iii) 2290 MHz band

- co-primary allocation to the fixed, mobile (except aeronautical mobile) and space research (deep space and space to earth) services at 2290-2300 MHz;
- co-primary allocation to the fixed and mobile services at 2300-2302 MHz; and
- secondary allocations to the amateur and radiolocation services at 2300-2302 MHz.

4.18 As discussed in the section 2, the 2.6 GHz and 2010 MHz bands were identified internationally for use by administrations wishing to implement IMT-2000 as a result of the ITU World Radio Conference of 2000. However, the conference did not mandate the use of IMT-2000 technologies in these bands.

4.19 There are no international regulatory measures that specifically cover the 2290 MHz band other than those in the ITU framework. However, as set out below, ECC Decision (06)04 on ultra wide band is relevant to the 2290 MHz band.

CEPT allocations

4.20 The European Table of Frequency Allocation[53] is developed by the ECC on the basis of the ITU RRs and records potential further regulatory measures decided within CEPT. The European common allocations for the three bands are:

a) at 2500-2690 MHz, some differences have been introduced compared to the ITU RRs, with a removal of the allocation to mobile satellite and broadcasting satellite across 2500-2690 MHz, a change of the fixed allocation from primary to secondary at 2500-2520 MHz and 2670-2690 MHz and a removal of the secondary allocations to earth exploration satellite and space research (passive) at 2670-2690 MHz, and the European common allocations are:

- primary allocation to the mobile service (except aeronautical mobile) at 2500-2690 MHz;
- primary allocation to the fixed service at 2520-2670 MHz;
- secondary allocation to the fixed service at 2500-2520 MHz and 2670-2690 MHz;
- secondary allocations to the earth exploration satellite (passive), radio astronomy and space research (passive) services at 2655-2670 MHz; and
- secondary allocation to the radio astronomy service at 2670-2690 MHz;

b) at 2010-2025 MHz, as per the ITU RRs (see above); and

c) at 2290-2302 MHz, as per the ITU RRs (see above).

4.21 The European Table of Frequency Allocation records the fact that the 2.6 GHz band has not been considered within CEPT for satellite applications.

4.22 The European Table of Frequency Allocation is made available for information, and as with CEPT decisions, it is not binding on the member countries.

Existing CEPT decisions

Decisions on the 2.6 GHz band

4.23 There are two decisions of the CEPT that are relevant to the 2.6 GHz band.

4.24 ECC Decision (02)06, adopted in November 2002, designates the 2.6 GHz band for UMTS/IMT-2000 systems and specifies that it should be made available for use by 1 January 2008 subject to market demand and national licensing schemes.

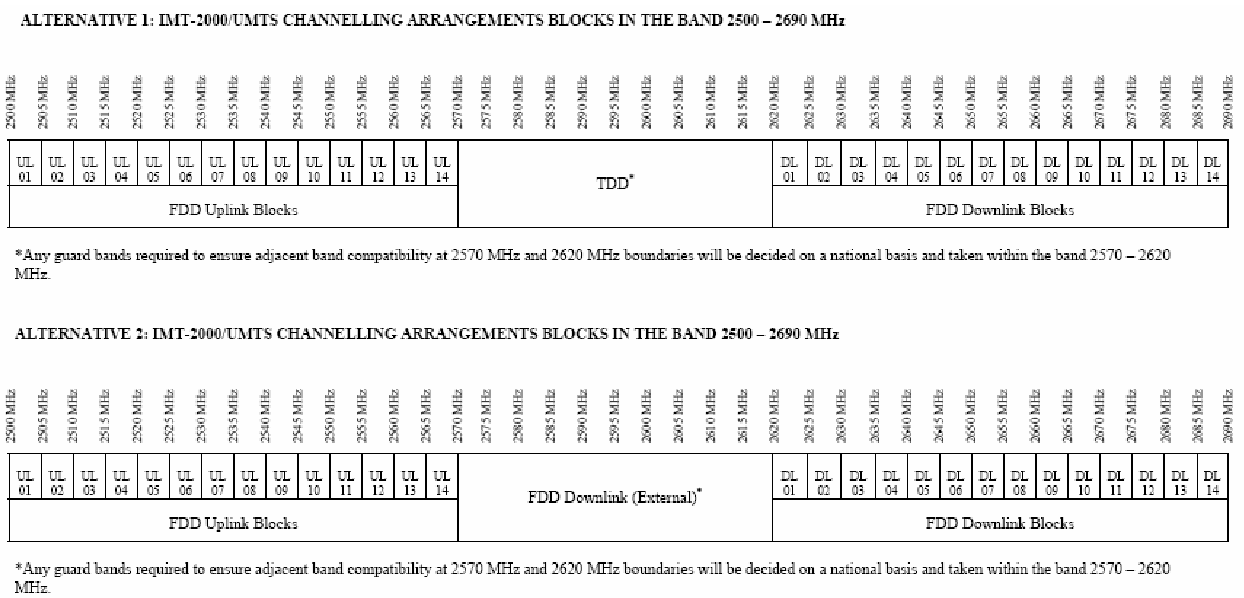
4.25 ECC Decision (05)05, adopted in March 2005, reiterates the provisions of Decision (02)06 regarding designation for UMTS/IMT-2000 and timing for making the band available, but also includes a specific band plan. The decision identifies two alternative versions of the band plan, one with spectrum for Frequency Division Duplex (FDD) use and Time Division Duplex (TDD) use, another with spectrum for FDD use only (see figure below).

[53] The table (version Copenhagen 2004) is available on the ERO website, at http://www.ero.dk/eca-change.

i) Alternative 1 with FDD and TDD use. It includes 14 paired channels of 5 MHz FDD use at 2500-2570 MHz for uplink (mobile transmit) and 2620-2690 MHz for downlink (base transmit), with a fixed duplex spacing of 120 MHz (i.e. the first uplink channel at 2500-2505 MHz is paired with the first downlink channel at 2620-2625 MHz until the fourteenth uplink channel at 2565-2570 MHz paired with the fourteenth downlink channel at 2685-2690 MHz). The TDD block within the band is of 50 MHz at 2570-2620 MHz and the Decision specifies that "any guard bands required to ensure adjacent band compatibility at 2570 MHz and 2620 MHz boundaries will be decided on a national basis and taken within the band 2570 – 2620 MHz".

ii) Alternative 2 with paired FDD and FDD to be paired with another band. It includes the same FDD arrangements as above, with 2 x 70 MHz at 2500-2570 MHz for uplink and 2620-2690 MHz for downlink, and with a fixed duplex spacing of 120 MHz. The difference lies in the use of the centre block at 2570-2620 MHz, which in this case is identified for FDD downlink (base transmit), to be paired with another band. The decision does not identify which band could be paired with 2570-2620 MHz for FDD use. Again the decision specifies that "any guard bands required to ensure adjacent band compatibility at 2570 MHz and 2620 MHz boundaries will be decided on a national basis and taken within the band 2570 – 2620 MHz".

Figure 3: band plans for the 2.6 GHz band in ECC Decision (05)05



4.26 Article 12.3bis.1 of the ECC rules of procedure[54] states that "each Decision shall be reviewed by the ECC every three years from its date of adoption to determine the extent of its implementation and the take-up of any frequency bands designated in the Decision, taking account of an initial assessment made by the Office [the ERO], and any other relevant information. As a consequence of this review the ECC Plenary shall decide whether to maintain, revise or abrogate the Decision." There are no sunset clauses contained in either ECC Decision (02)06 or ECC Decision (05)05 and they will remain in place until such time as the ECC decides they should be withdrawn or amended.

[54] Edition 4 dated 28 October 2005, available at http://www.ero.dk/468ed5b1-bace-4875-b44a-a82854c30e10?mid=050DAFE4-FA3A-43E6-8992-59569A60C3C2&frames=no.

4.27 The ECC rules of procedure also provide some information on the interpretation of ECC decisions. At article 12.1.1, it is specified that "decisions should neither impose nor discriminate in favour of the use of a particular type of technology, although this does not preclude the taking of proportionate steps to promote certain specific services where this is justified". Article 12.1.1bis sets out that "decisions that "designate" a frequency band for a harmonised application are intended to foster the deployment of an application to meet a market demand in a harmonised manner throughout CEPT. Members signing the Decision commit themselves to make spectrum available for this harmonised application which includes assessing when and where there is a demand for the harmonised service/application and deciding whether that demand is great enough to exclude other services and applications from the harmonised band. Such Decisions shall not inhibit radiocommunication equipment meeting different standards from operating in an identified frequency band provided it offers the same spectrum use and application as specified in a Decision for the band and is placed on the market in conformity with the essential requirements i.e. it makes effective use of the spectrum allocated to terrestrial/space radio communications so as to avoid harmful interference".

4.28 The UK is not committed to implementing ECC Decision (02)06 or ECC Decision (05)05.

Decisions on the 2010 MHz band

4.29 Since publication of the SFR:IP Interim Statement, ECC Decision (99)25 that was relevant to this band has been withdrawn, as the licence-exempt systems envisaged for self-coordinated, self-provided applications were not developed or adopted. ECC Decision (99)25 has now been replaced by ECC Decision (06)01[55], which designates the 2010 MHz band for IMT-2000/UMTS systems and identifies it for either TDD use or FDD uplink (mobile transmit). Use of the 2010 MHz band for FDD uplink would be paired with another frequency band used for the associated FDD downlink. Decision (06)01 does not identify a specific band for that purpose but cites 2570-2620 MHz as an example of a band where the FDD pairing could be implemented. Subject to market demand and national licensing scheme, Decision (06)01 identifies the 2010 MHz band as available for IMT-2000/UMTS systems from the date of entry into force of the decision, 24 March 2006.

4.30 The UK is not committed to implementing ECC Decision (06)01.

Other decision relevant to the 2.6 GHz, 2010 MHz and 2290 MHz band - UWB

4.31 Work in Europe on ultra wide band (UWB) has been ongoing for some time[56]. In March 2006, pursuant to two mandates from the EC[57], CEPT adopted ECC Decision (06)04 on the harmonised conditions for devices using UWB technology in bands below 10.6 GHz. CEPT developed this decision in response to an EC mandate to CEPT to identify the conditions relating to the harmonised introduction in the

[55] http://www.ero.dk/documentation/docs/docfiles.asp?docid=2149&wd=N
[56] Information on Ofcom's position in the debate on UWB can be found at http://www.ofcom.org.uk/consult/condocs/uwb/. This includes a consultation document on the scope for introducing UWB in the UK published in January 2005; a summary of responses and Ofcom's reaction published in June 2005 and a document prepared by Ofcom as an input to CEPT discussions published in September 2006.
[57] Mandates from the EC to CEPT of 18 February 2004 and 6 June 2005 relevant to UWB, available at http://europa.eu.int/information_society/policy/radio_spectrum/activities/rsc_work/mandates/index_en.htm.

European Union of radio applications based on UWB technology. ECC Decision (06)04 may form the basis for a draft EC Spectrum Decision on harmonised conditions for devices using UWB technology in the 6-8.5 GHz band.

4.32 ECC Decision (06)04 establishes the maximum EIRP density (dBm/ MHz) that should be allowed for various bands below 10.6 GHz. The range 1.6 – 3.8 GHz covers all three of the bands under consideration for award in this document. The values proposed in this frequency range are:

- a maximum mean EIRP density of -85 dBm/ MHz; and
- a maximum peak EIRP density of -45 dBm/50 MHz.

4.33 Decision (06)04 notes that the ECC is still considering whether or not to adopt a separate Decision covering the frequency band 3.1 – 4.8 GHz. Further work is ongoing with a view to allow UWB devices that provide corresponding mitigation a higher maximum EIRP density when operating in this range only.

4.34 Following a third mandate from the EC on UWB[58], CEPT is developing further a decision for UWB technology with additional mitigation requirements that would permit use in the range 3.1-4.8 GHz band. The decision would likely include provisions on emissions in the 2.6 GHz, 2010 MHz and 2290 MHz bands. This further work is focussing on a solution which includes a ‘detect and avoid’ mitigation technique to reduce interference to other in-band services. It includes consideration of whether the out-of-band power level of a UWB device operating at 3.1 to 4.8 GHz may be increased from the level of -85dBm/ MHz in ECC Decision (06)04 to -70dBm/ MHz.

4.35 In response to the relevant EC mandates, CEPT is developing draft ECC decisions for licensed imaging systems using ground-probing and wall-probing radars and unlicensed building material analysis devices. The technical provisions of those decisions are also likely to include provisions on UWB emissions in the 2.6 GHz, 2010 MHz and 2290 MHz bands.

Potential future EU provisions

4.36 Since 2005 the use of the 2.6 GHz band, in particular, has been the subject of discussions at the EU level. The European Commission has put forward proposals for a binding RSC Decision in relation to the 2.6 GHz band. However, it has not been possible for the RSC to reach agreement on the proposals. The 2.6 GHz band is now being considered alongside other bands as part of the WAPECS mandate issued by the EC to CEPT to consider the technical conditions under which the bands could be used for mobile communications, as explained below.

4.37 Other relevant EU discussions relate to the introduction of UWB which could be permitted to operate across a range of frequencies which includes the bands for award.

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[58] Mandate of 5 July 2006, available at http://europa.eu.int/information_society/policy/radio_spectrum/activities/rsc_work/mandates/index_en.htm.

Potential decision relevant to the 2.6 GHz and 2010 MHz bands – WAPECS work

4.38 As discussed above, work in CEPT under mandate from the European Commission on the 2.6 GHz band resulted in the development of ECC Decisions (02)06 and (05)05 designating the band for IMT-2000/UMTS. The report accompanying Decision (05)05 from the CEPT to the Commission (CEPT Report 002[59] of 12 November 2004) highlighted divergent views within CEPT on use of the band by technologies other than IMT-2000/UMTS. The UK was in favour of allowing other technologies in the band provided that they would not cause more interference or require greater protection than IMT-2000/UMTS. In its covering letter to the Commission, the ECC highlighted the view that administrations adopting the Decision were not precluded from authorising alternative technologies within the band (the UK has decided not to implement ECC Decision (05)05).

4.39 Debate within the RSC following the CEPT work has failed to reach agreement on a binding Commission Decision for the band. The Commission was in favour of a decision which would allow technologies and applications other than IMT-2000/UMTS to use the band (see for example RSCOM05-18[60]). The EC sought views from stakeholders in June 2005 and published an invitation to comment on the benefits of either allowing a wide range of technologies in the 2.6 GHz band or restricting technologies to those in the IMT-2000 family. The EC prepared a summary of the comments received[61], which showed diverging views amongst European regulators as well as industry members. Due to the lack of consensus in the RSC (see for example RSCOM05-45[62] and RSCOM05-81[63]), the EC has now decided to withdraw its proposal for a binding Decision and has subsumed further work on the 2.6 GHz band within the ongoing work on the implementation of the Wireless Access Policy for Electronic Communications Services (WAPECS) concept.

4.40 The WAPECS concept was introduced in an opinion of the RSPG[64], with the objective of providing a policy framework for the provision of electronic communications services within a set of frequency bands to be identified and agreed between Member States. The framework is designed to ensure effective and efficient use of the spectrum and based on the principle of technology and service neutrality, i.e. that there should be no restrictions on the potential technologies to be used or services to be offered in those bands (subject to such factors as the avoidance of interference or the avoidance of distortion of competition as a result of authorisation conditions). The long term policy goals identified in the opinion include to facilitate access to spectrum for new technologies to promote competitiveness, to ensure a coherent authorisation scheme, to remove constraints attached to the usage of

[59] http://www.ero.dk/documentation/docs/docfiles.asp?docid=2076&wd=N
[60] EC document of 18 May 2005, section 2.1, available at http://forum.europa.eu.int/Public/irc/infso/radiospectrum/library?l=/public_documents_2005/rsc12_june_2005/rscom05-18_imt-2000pdf/_EN_1.0_&a=d.
[61] See RSCOM05-44rev1 of 28 October 2006 available at http://forum.europa.eu.int/Public/irc/infso/radiospectrum/library?l=/public_documents_2005/rsc13_october_2005/rscom05-44rev1_imt-2000p/_EN_1.0_&a=d.
[62] EC document of 3 October 2005 available at http://forum.europa.eu.int/Public/irc/infso/radiospectrum/library?l=/public_documents_2005/rsc13_october_2005/rscom05-45_imt-2000/_EN_1.0_&a=d.
[63] EC document of 9 December 2005 available at http://forum.europa.eu.int/Public/irc/infso/radiospectrum/library?l=/public_documents_2005/rsc14_december_2005/rscom05-81_wapecspdf/_EN_1.0_&a=d.
[64] See document RSPG05-102 final of 23 November 2005, available at http://rspg.groups.eu.int/rspg_opinions/index_en.htm.

specific radio spectrum bands wherever possible and to ensure flexibility in use of the WAPECS frequency bands both in terms of technologies that can be used and services that can be provided (subject to restrictions that can be duly justified).

4.41 Following the 16th meeting of the RSC in June 2006 and as part of the implementation plan for the RSPG opinion, the EC issued a mandate[65] to CEPT on WAPECS to develop least restrictive technical conditions for frequency bands addressed in the context of WAPECS, which covers several spectrum bands, including the 2.6 GHz and 2010 MHz bands.

4.42 The bands included within the scope of the mandate are:

- 470-862 MHz;
- 880-915 MHz / 925-960 MHz (2G 900 MHz bands);
- 1710-1785 MHz / 1805-1880 MHz (2G 1800 MHz bands);
- 1900-1980 MHz / 2010-2025 MHz / 2110-2170 MHz (2 GHz bands);
- 2500-2690 MHz; and
- 3.4-3.8 GHz.

4.43 Under the mandate, CEPT is required to:

i) review existing technical conditions attached to the rights of use of the frequency bands covered by the mandate;

ii) to the extent possible, to identify future common and minimal (i.e. least restrictive) technical conditions across the frequency bands covered, in the spirit of Article 1 of the Authorisation Directive, to become ultimately applicable throughout the Community and to justify any deviations from the long term policy goals contained in the RSPG opinion on WAPECS;

iii) noting that results are urgently needed for the 2nd generation mobile bands, study and confirm the technical feasibility and support for operating technologies other than GSM in the bands currently used for 2nd generation mobile services and develop a channelling arrangement including all technical elements needed in order to facilitate a common approach within the Community; and

iv) if time and resources allow, consider the band 1800-1805 MHz (upper TFTS band) in the context of this Mandate.

4.44 CEPT was requested to produce an interim report on i) and iii) by 5 December 2006 and a final report on all points by 29 July 2007.

4.45 The EC also issued a liaison statement for the attention of COCOM. The purpose of the liaison is for the RSC to receive input from the COCOM on existing conditions attached to spectrum authorisations for the bands covered in the WAPECS initiative

[65] The mandate dated 5 July 2006 is available at http://europa.eu.int/information_society/policy/radio_spectrum/docs/current/mandates/ec_to_cept_wapecs_06_06.pdf.

and consider to what extent these could be changed as part of the implementation of the WAPECS concept.

4.46 The Commission has also recently brought the issue back to RSC with a proposal to the December 2006 meeting to send a questionnaire to Member States requesting information on their plans to award the band including the status of existing use, demand for future use, future technical conditions and the timing of any future award.

4.47 It is possible that, having received information from member states and the input from CEPT and COCOM, the EC may consider, along with the RSC, further options for a binding decision for the 2.6 GHz and 2010 MHz bands, as well as other bands under the WAPECS concept.

4.48 The potential exists for this process to lead, ultimately, to the RSC making a Decision on harmonising the spectrum in a way that constrains the manner in which the 2.6 GHz band can be used.

4.49 General discussions on the 2.6 GHz band have also taken place in the RSPG at its meeting of 25 October 2006. The RSPG may consider the issues further and provide some input to the RSC consideration of the 2.6 GHz band and its work on WAPECS more generally.

4.50 The implications of a potential future RSC decision for the timing of an award for the 2.6 GHz and 2010 MHz bands in the UK are considered in section 6.

Potential decisions relevant to the three available bands - UWB

4.51 Within the EU, the RSC has been discussing proposals for a Decision covering frequencies above 6 GHz to take forward CEPT's work on UWB and ECC Decision (06)04.

4.52 As a result of the CEPT responses to the various EC Mandates on UWB discussed at paragraphs 4.31 to 4.35, the EC may introduce one or more harmonisation measures in the form of decision of the RSC which would normally be binding on member states and could include provisions on emissions in the 2.6 GHz, 2010 MHz and 2290 MHz bands. A draft proposal for such a Decision has been presented to the December 2006 meeting of the RSC.

4.53 This first of these measures was adopted by the RSC at its meeting on 4 and 5 December 2006. Ofcom understands that the Commission Decision is likely to be published in the Official Journal of the European Union around the end of January 2007.

Section 5

Uses in the spectrum bands and adjacent spectrum

5.1 This section presents an analysis of the technical constraints that are created by the existence of other allocations and spectrum uses in so far as these impact on the way that the spectrum within the 2.6 GHz, 2010 MHz and 2290 MHz bands can be made available for award. As the table below summarises, this requires an analysis of spectrum uses (both existing uses, and potential future uses), with which the winners of these awards would need to cohabit that are:

- located in either UK or in a neighbouring country; and
- within the bands being made available for award (“in-band” uses) or adjacent to the bands being made available for award (“adjacent” uses).

	In-Band	**Adjacent**
UK	Shared use of the same frequencies in similar locations is usually not possible without causing harmful interference. Mitigation measures may permit some band sharing. Coexistence of uses is in accordance with relevant authorisation decisions, including provisions recorded in the UK frequency allocation table.	Uses which are in adjacent frequencies in similar locations can interfere with each other, mainly because transmitting equipment will have some “out-of-band” emissions and this can interfere with receivers in the adjacent band.
International (neighbouring country)	Although physical separation reduces the chances of interference where users are operating on the same frequency, the propagation of radio signals means that there is still scope for harmful interference across international borders.	Where there is both physical and frequency separation the chances of harmful interference are greatly reduced. However, it can still occur and requires analysis.

5.2 Where there is the potential for harmful interference to occur, the implications for the conditions under which the spectrum can be awarded depend on the following.

a) The relative allocation priorities attaching to the different uses. These priorities are set both internationally (principally under the ITU RRs) and nationally (as recorded from time to time in the UK Frequency Allocation Table, the current issue of which is 2004, Issue No. 13 (UKFAT)).

b) The chronology since, when different uses have the same priority ranking in the regulatory framework, then the earlier use generally has rights over the later use.

c) The scope for mitigation of harmful interference, for example through coordination or technical restrictions on uses.

5.3 This section, therefore, considers the 2.6 GHz, 2010 MHz and 2290 MHz bands in turn and, for each of these, presents an assessment of the constraints (if any) that might be caused by:

- UK allocations and uses within the bands;
- international allocations and uses within the bands; and
- uses in adjacent bands, principally in UK, but also in neighbouring countries where relevant.

5.4 For each band, we provide a view on the likely implications for the awards. These can take the form of limitations on the conditions of transmission in parts of the spectrum for award, e.g. if there is a need to include restricted technical usage conditions for certain frequencies. These constraints are then captured in the packaging proposals in section 7 and in the regulatory conditions for use in section 9.

Reference sources for the technical analysis

5.5 The sections below detail the current status and uses in each band and the various national and international allocations and assignments within the bands and in adjacent bands. UK allocation and assignments information is taken from the UKFAT. Internationally, assignment information is contained in Article 5 of the ITU RRs and information on use in Europe in the European Common Allocation Table (see section 4).

5.6 In general, bands are allocated by the ITU to services on either a primary or secondary basis. Primary services are generally notated in upper case letters, e.g. MOBILE, FIXED, etc. Secondary services are noted in lower case letters, e.g. radio astronomy, Earth exploration satellite, etc.

5.7 In many cases where bands are allocated to different services on a co-primary basis the ITU RRs define coordination procedures that must be followed. These often set a coordination threshold or limit above which any new stations must be coordinated with administrations with registered primary services which might be affected. Additionally, regional bodies such as CEPT may establish recommendations on cross border coordination procedures between administrations. For instance ERC Recommendation 01-01 establishes coordination principles to facilitate UMTS use on either side of a national border, the aim being to allow the roll out of services on both sides of the border without unacceptable levels of interference being generated.

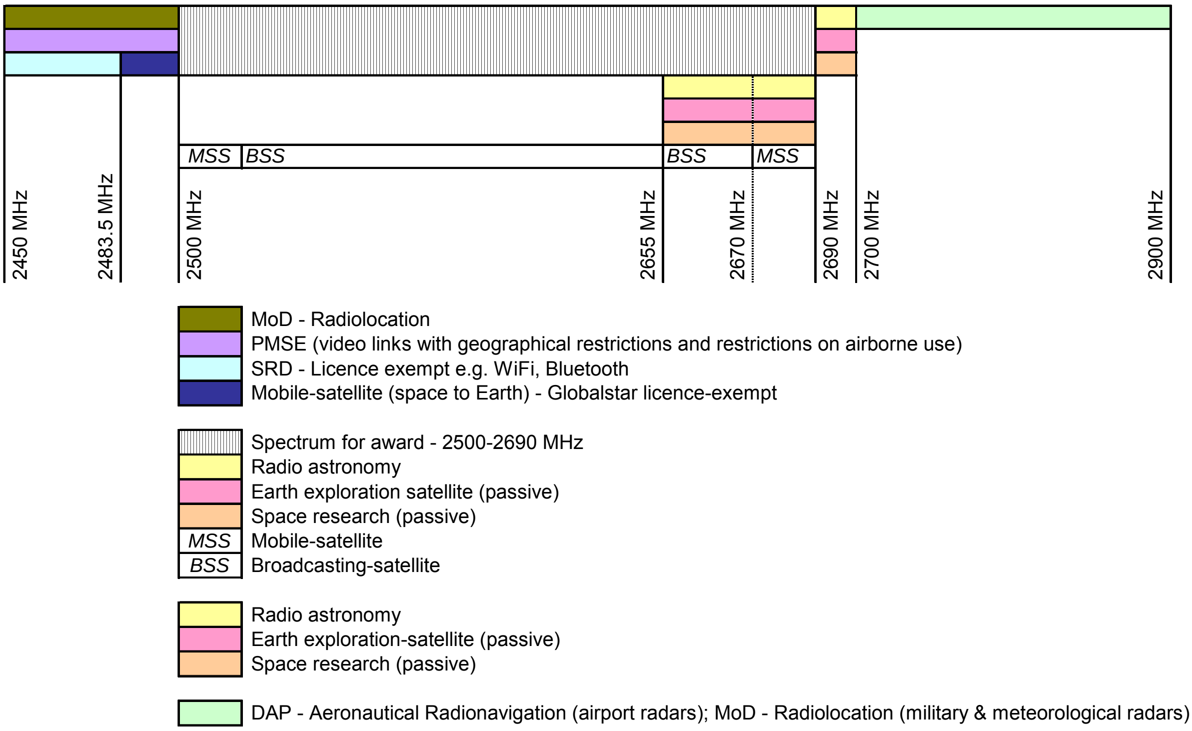
5.8 CEPT cross border coordination recommendations provide a framework for managing interference between primary services in different administrations but, by their nature, they are generic documents applicable to the technologies that may be recommended by the CEPT for a particular frequency band and are not designed to take account of the individual circumstances across a specific border. The UK therefore, when necessary, establishes specific Memoranda of Understanding (MoU) on cross border coordination with our nearest neighbours such as France and the Republic of Ireland; these are usually based on the relevant CEPT recommendation but may provide additional measures to deal with individual circumstances. For instance, the UK has negotiated MoUs on GSM and UMTS with France and Ireland which establishes preferred frequencies and codes where operators may transmit higher powers and non-preferred frequencies and codes where operators must respect much tighter controls on emissions. The intention is to share the available spectrum resource equally across the border area balancing the needs of the licensees in the UK and users in the neighbouring administration.

Technical analysis for 2500-2690 MHz

UK allocations and uses

5.9 The figure below illustrates the current allocations within the 2.6 GHz band and is based on the UKFAT.

Figure 4: service allocations for the 2.6 GHz band and adjacent spectrum



5.10 As indicated section 2 above, there is some current in-band use of the 2.6 GHz band by PMSE and MoD, however, both uses will have ceased by the date of the award.

<u>Passive services (secondary allocations at 2655-2690 MHz)</u>

5.11 The band 2655 – 2690 MHz, is allocated to Radio astronomy, Earth Exploration Satellite and Space Research on a secondary basis in the UK according to the UKFAT.

5.12 In the sub-band 2670 – 2690 MHz, PPARC-funded radio astronomy sites have previously been granted the category C protection status (i.e. all practicable measures will be taken to protect the radio astronomy service from harmful interference when planning assignments within the band) in the UKFAT. However, after discussion with the radio astronomy community it has been decided to downgrade the protection status to category D (i.e. no protection).

5.13 Given the secondary nature of the allocations to passive services and the fact that there appears to be no current use of the band by these services, Ofcom is not proposing to offer any protection to them from future use of the 2.6 GHz band.

International allocations and uses

5.14 The 2.6 GHz band is allocated on a primary basis to the FIXED and MOBILE services in all three ITU world regions. Parts of the band are also allocated to MOBILE-SATELLITE and BROADCASTING-SATELLITE in ITU Region 1 which includes Europe. Within the ITU RRs, the band has been identified on a world wide basis for IMT-2000.

5.15 The band is the subject of an agenda item (agenda item 1.9) at the next World Radiocommunications Conference in 2007 (WRC-07). This item covers the review of technical, operational and regulatory provisions applicable to the use of the band 2500 – 2690 MHz by space services in order to facilitate sharing with current and future terrestrial services without placing undue constraint on the services to which the band is allocated. Within CEPT the primary objective of this agenda item is to ensure that the regulatory provisions applicable to satellite use of the 2.6 GHz band within the ITU RRs provide sufficient protection to terrestrial services. The current CEPT position is to propose ‘hard’ power flux density (pfd) limits for satellite systems at a level guaranteed not to cause an interference issue for terrestrial services in Europe from satellite services elsewhere.

5.16 In Europe, no satellite use within the band has been made and none is planned (see ECAT – ERC Report 25). In particular mobile satellite use in the sub bands 2500 – 2520 MHz and 2670 – 2690 MHz was discounted when ECC Decision (05)05 was drafted. It is expected that most European countries will award the band for new uses in the near future. Some award processes may begin in 2007, others in 2008 or later. It should be noted that future flexible use of band is being studied by CEPT under the WAPECS mandate, with the aim of establishing a common, minimal (i.e. least restrictive) set of technical conditions to become ultimately applicable across the European Union.

5.17 Within the Republic of Ireland the band is used by the Multimedia Distribution Service (MMDS). MMDS is a TV broadcast distribution service. Currently there are two Irish operators Chorus and NTL who provide services to about 110,000 subscribers using that technology. Ofcom understands that Chorus’ and NTL’s licences expire in 2014 and they can be renewed on application by the operators. At the present time it seems appropriate to assume that this use of the band in the Republic of Ireland will continue for the foreseeable future. Ofcom has held preliminary discussions with the Irish communications regulator, ComReg, with the aim of establishing a cross border MoU to manage interference. It is hoped that an MoU based on the limits from CEPT Recommendation 01-01 will be established in the near future. The separate technical report published alongside this consultation provides an analysis of the interference potential into the United Kingdom from the MMDS service. However, it should be noted that this is very much a worst case analysis based on the powers and antenna heights and locations derived from the Irish MMDS planning guidelines document. In order for Ofcom to conduct a more realistic interference assessment, we have asked the Irish regulator, ComReg, to request detailed deployment information from the MMDS operators. Ofcom plans to publish an updated interference assessment when the further information is available.

5.18 Ofcom has held preliminary discussions with the French regulator (ANFR) on current and future use of the band. There are a number of military fixed links in the band that the French regulator would like protection for and Ofcom is currently working to develop a cross border MoU. As well as the protection of existing services, this should provide a framework for future use based on the limits from CEPT Recommendation 01-01. Ofcom understands that the French have not yet set a date for the future award of spectrum in the band. However, France has committed to implement ECC Decision (05)05 and the following text appears on the ERO website in relation to this Decision*: "The frequency band will be available after 2008 subject to market demand. The French table of frequency allocation will refer to the ECC Decision in its next version to be adopted in late 2006. Information will be published on the ARCEP web site: www.arcep.fr".*

Uses adjacent to 2500-2690 MHz

MoD radiolocation (2450-2500 MHz)

5.19 The UKFAT indicates that band 2450 – 2500 MHz is used by the MoD for the radiolocation service. However, information from the MoD indicates that they have no current radiolocation assignments in this band.

Programme Making and Special Events (2450-2500 MHz)

5.20 The band 2450 – 2500 MHz is used for services for Programme Making and Special Events (PMSE). The band is available for 10 MHz digital video links with an EIRP up to 20 dBW.

5.21 Ofcom's technical advisers have conducted an interference analysis based on the following types of PMSE use:

- point to point temporary video links (coordinated, EIRP 20 dBW);
- airborne (air-to-ground) video links (EIRP 7 dBW);
- portable/mobile video links (EIRP 6 dBW); and
- wireless cameras (EIRP 0 dBW).

5.22 The result of this analysis is that there is a potential for interference from PMSE use into the 1st and 2nd adjacent 5 MHz channels at the 2500 MHz boundary and that base stations transmitting in the 1st and 2nd adjacent channels at the 2500 MHz boundary will cause interference into PMSE. Separation distances of more than 100 metres are typically needed for many of the interference scenarios considered (excluding PMSE airborne use where separation distances of greater than 1 km may be needed). However, interference can be mitigated against by the use of channel or band filters by PMSE users. Use of a 30 dB filter reduces the separation distances considerably to the point where interference between the two uses should not be a major issue, though PMSE airborne use may still be problematical and may need to be restricted in the immediately adjacent channel 2490 – 2500 MHz. See the separate technical report published alongside this consultation for details of the interference analysis.

5.23 It should be noted that, with the exception of PMSE airborne use, the worst interference cases arise when the lower two 5 MHz channels of the 2.6 GHz band are used for base station transmit (either FDD or TDD). Ofcom is not proposing to allow FDD base transmit in this portion of the band and TDD base transmit will only occur if the demand for unpaired spectrum completely dominates the demand for paired spectrum and hence the entire 2.6 GHz band is awarded for unpaired use.

5.24 As result of Ofcom's proposed award process, if all lots in the 2.6 GHz band were to be used for unpaired, restrictions would apply to base station transmissions in the bottom two 5 MHz lots at 2500-2505 and 2505-2510 MHz (see section 7 for details) which would also serve protect PMSE use.

Short Range Devices (2450-2483.5 MHz)

5.25 The band 2450 – 2483.5 MHz is used for a range of licence-exempt short range devices including Wireless Local Area Network (WLAN) based on the IEEE 802.11 standard otherwise known as WiFi and Bluetooth. The band is also used for a range of Industrial, Scientific and Medical (ISM) devices. Short range devices can only operate at a limited maximum power, typically 10 dBm eirp, and are separated from the bottom edge of the 2.6 GHz band by 16.5 MHz. It is not anticipated that they will pose a significant interference threat. Due to the frequency separation it is also very unlikely that use in the 2.6 GHz band will be a significant source of interference to these short range devices. Additionally, licence exempt devices operate on a non-interference, non-protection basis (see SI 2003/74 Licence Exemption Regulations and interface requirement IR 2016) and as a consequence, Ofcom is not obliged to protect them from interference from new use in the 2.6 GHz band.

Mobile satellite – Globalstar (2483.5-2500 MHz)

5.26 The band 2483.5 – 2500 MHz is allocated on a primary basis to the MOBILE SATELLITE service (MSS) in all three ITU regions and used by the Globalstar system. The 2483.5 – 2500 MHz band provides the space-Earth link for this system.

5.27 Interference analysis by the Consultants indicates that there is potential for use of the lower two 5 MHz channels of the 2.6 GHz band to cause interference to MSS handsets. Separation distances of greater than 500 metres would be required to avoid interference from TDD base transmit. However, these circumstances would only arise if the whole 2.6 GHz band were awarded for unpaired use. The likelihood of this seems low and under Ofcom's proposals, the bottom two lots at 2500-2505 and 2505-2510 MHz would be subject to specific restrictions under these circumstances, which would provide mitigation.

5.28 The risk of interference to MSS handsets from mobile use at the bottom of the 2.6 GHz band is limited to a few tens of metres. Given the low density of MSS handsets in service, the risk of interference is likely to be sufficiently small as to not warrant any restrictions on mobile use in the 2.6 GHz band.

Radio astronomy – passive (2690-2700 MHz)

5.29 This band is allocated to the RADIO ASTRONOMY service on a primary basis in the UKFAT and assigns it category A protection (i.e. the full protection afforded a primary or exclusive Radiocommunications allocation). Radio astronomy observatories listed are at Cambridge, Darnhall, Defford, Jodrell Bank, Knockin and Pickmere. They are listed as used for mapping radio sources, pulsars, and possibly MERLIN. However, information from the UK radio astronomy community indicates there is no current use and the band is not a priority for UK radio astronomy use. There are no plans for future research projects in the band at UK observatories.

5.30 Because of the low priority given to the band by the radio astronomy community in the UK for the observatories listed in the UKFAT and of the absence of any significant use, it has been decided that there is no need to place restrictions on transmissions from the 2.6 GHz band to protect Radioastronomy in the UK.

5.31 Within Europe, the band is used for radio astronomy observations and Ofcom needs to ensure that future use in the band will not cause harmful interference into continental radio telescopes. Ofcom has conducted an analysis of interference based on ITU-R Recommendation RA.769-2, Protection Criteria for Radio Astronomical Measurements, with an interference criterion of -207 dBW in a bandwidth of 10 MHz. This analysis demonstrates that the aggregate out-of-band emissions from FDD or TDD base stations would not exceed the interference threshold at any of the European radio telescope sites listed on the CRAF[66] website[67]. See the separate technical report published alongside this consultation for details of the interference analysis.

Earth Exploration Satellite – passive (2690-2700 MHz)

5.32 This band is allocated to the EARTH EXPLORATION SATELLITE service (EESS) on a primary basis in the UKFAT. However, Ofcom understands that there is no current or planned use within the UK.

5.33 Given the absence of any significant use Ofcom considers that there is no need to place restrictions on transmissions from the 2.6 GHz band to protect EESS use in the UK.

5.34 Ofcom has analysed the potential impact of use of the 2.6 GHz band on international EESS use and has concluded that the risk of harmful interference is very small (based on the protection criteria given in ITU-R Recommendation SA.1029-2). See the separate technical report published alongside this consultation for details of the interference analysis.

Space Research – passive (2690-2700 MHz)

5.35 This band is allocated to the SPACE RESEARCH (passive) service on a primary basis in the UKFAT.

5.36 Within the UK there is no identified use of this allocation. Given the absence of any significant use Ofcom considers that there is no need to place restrictions on transmissions from the 2.6 GHz band to protect space research - passive use in the UK.

5.37 Ofcom does not consider use of the 2.6 GHz band will impact on international space research - passive use.

Aeronautical radionavigation and Radiolocation (2700-2900 MHz)

5.38 The band 2700 to 2900 MHz has a primary allocation to AERONAUTICAL RADIONAVIGATION and a secondary allocation to radiolocation. This band is used by the Civil Aviation Authority (CAA) / National Air Traffic Services (NATS) for air traffic control radars and MoD. The band is also used for meteorological and other military radars. The CAA co-ordinates use of the band on behalf of Ofcom.

[66] Committee on Radio Astronomy Frequencies
[67] http://www.astron.nl/craf/raobs.htm

5.39 The relevant interface requirement, IR2050, notes that frequency planning assumptions are in accordance with ITU RRs Appendix 3, Recommendation ITU-R SM. 329-10 (Unwanted emissions in the spurious domain) and Recommendation ITU-R SM.1541-1 (Unwanted emissions in the out-of-band domain). IR2050 suggests that manufacturers refer to the appropriate volumes of Annex 10 to the Convention on International Civil Aviation, aeronautical telecommunications, as amended, for relevant manufacturing standards and guidelines.

5.40 Ofcom has conducted an analysis of the interference potential from radar transmissions in this band to equipment in the 2.6 GHz band. The conclusions from this analysis are that for the three types of radar analysed (Magnetron, Travelling Wave Tube and Solid State) that interference will occur within certain areas of the country for the 2.6 GHz band. However, due to the pulsed nature of radars this interference will be of an intermittent nature. Magnetron and Travelling Wave Tube radars have a relatively short pulse duration compared for instance to the W-CDMA chip rate. These types of radar may cause an increase in the bit error rate but this should be well within the capabilities of the forward error correction of most modern communications systems such as W-CDMA and WiMAX to cope with. The other type of radar, Solid State, employs longer pulse durations but at lower power and have relatively better out of band characteristics. There are fewer of these radars deployed and their impact on the 2.6 GHz band is more difficult to predict – there is likely to be an increase in the bit error rate and the longer pulse durations may make it more difficult for forward error correction to compensate. See the separate technical report published alongside this consultation for details of the interference analysis.

Implications for the 2.6 GHz band award

5.41 The implications of the technical analysis for the award proposals are as follows.

- Most blocks will be available for typical high-power operation.

- At the 2500 MHz adjacency, no specific restrictions are proposed other than those described in section 7 on packaging regarding unpaired lots. The risk of interference between mobile stations (handsets) used in the 2.6 GHz band and PMSE may be addressed by filtering of PMSE equipment. The risk of interference between mobile stations (handsets) used in the 2.6 GHz band and MSS handsets below 2500 MHz is likely to be low because of the low density of MSS equipment. The risk of interference from base stations to PMSE or MSS would only be relevant if the whole 2.6 GHz band could be used for unpaired/TDD applications. In this case, the packaging proposals for unpaired use would provide for restrictions on the use of the bottom 5 MHz lot of the 2.6 GHz band and tighter out-of-band emissions for the second lot.

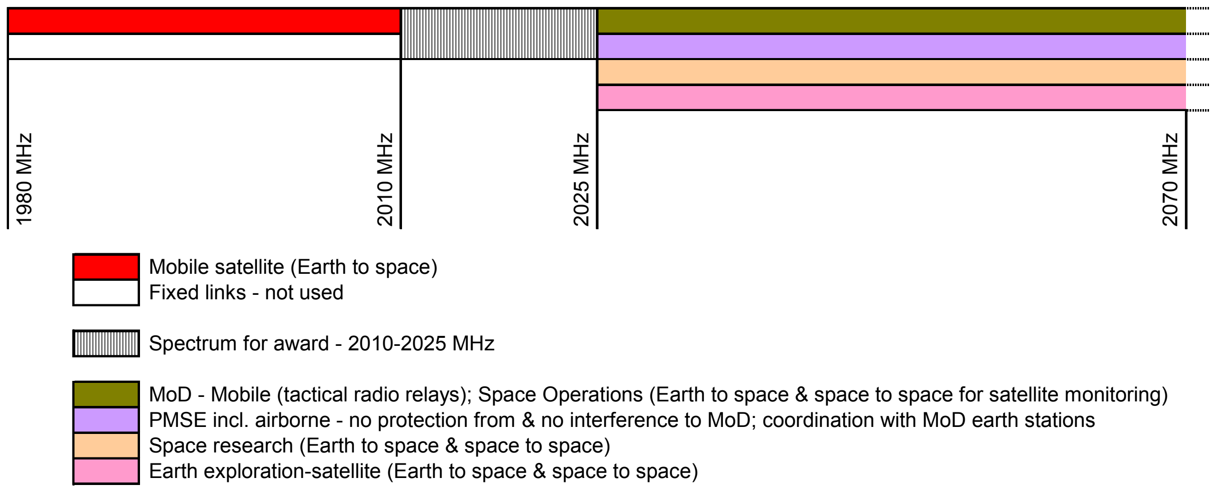
- At the 2690 MHz adjacency, no restrictions are necessary to protect Radioastronomy in the UK, as the band is not a priority to the radio astronomers there, or abroad, as Ofcom has not identified any material risk of interference. Also, no restrictions are necessary to protect aeronautical radar above the 2.6 GHz band as the frequency separation and proposed out-of-band mask are considered sufficient. There is a risk of interference from aeronautical radars into the 2.6 GHz band but this seems unlikely to be significant.

Technical analysis for 2010-2025 MHz

UK allocations and uses

5.42 The figure below illustrates the current allocations within the 2010 MHz band and is based on the UKFAT.

Figure 5: service allocations in the 2010 MHz band and adjacent spectrum



5.43 As indicated section 2 above, no assignments have been made in the band and it is effectively vacant.

International allocations and uses

5.44 The band 2010 – 2025 MHz is allocated on a primary basis to the FIXED and MOBILE services in all three ITU regions and to MOBILE SATELLITE (Earth to space) in Region 2. Within the ITU RRs, the band has been identified on a worldwide basis for IMT-2000.

5.45 Within Europe the band is allocated to IMT-2000 TDD applications but at present there is very little deployment. Some European countries awarded the upper 5 MHz (2020 – 2025 MHz) as part of their 3G spectrum awards at 2 GHz. In other countries the entire 15 MHz was held back for self-provided, self coordinating applications. It should be noted that future flexible use of band is being studied by CEPT under the WAPECS mandate, with the aim of establishing a common, minimal (i.e. least restrictive) set of technical conditions to become ultimately applicable across the European Union.

Uses adjacent to 2010-2025 MHz

Mobile satellite (1980-2010 MHz)

5.46 The band 1980 – 2010 MHz is allocated on a primary basis to the MOBILE SATELLITE service and is identified in the ITU RRs for the satellite component of IMT-2000[68]. The band is specified as a satellite uplink, i.e. Earth to space. Adjacent

[68] ITU RRs: the bands 1885-2025 MHz and 2110-2200 MHz are intended for use, on a worldwide basis, by administrations wishing to implement International Mobile Telecommunications-2000 (IMT-2000). Such use does not preclude the use of these bands by other services to which they are

band compatibility between UMTS and MSS was studied within CEPT and ERC Report 65 suggests that a 500 kHz guard band is necessary to prevent interference. This guard band is reflected in ECC Decision (06)01 which specifies that the nearest UMTS carrier to 2010 MHz should be centred on 2013 MHz or above. Ofcom intends to respect this by specifying that the out-of-band mask at the lower edge of the band 2010 – 2025 MHz should start 500 kHz inside the available spectrum.

5.47 Future use of the band has been the focus extensive discussion within the CEPT and EU. Within the EU, a Decision designating the above bands for Mobile Satellite Services, which may include a complementary ground component, may be adopted in December 2006, through the Radio Spectrum Committee (RSC). The selection and authorisation processes by which satellite systems are authorised in the band 1980 - 2010 MHz and 2170 – 2200 MHz are under development within the EU.

MoD for mobile and space operations (2025-2110 MHz)

5.48 The UKFAT has the following allocations to the MoD in this band:

- 2025 – 2070 MHz – MoD for the Mobile service; and
- 2025 – 2110 MHz – MoD for the Space Operations service.

5.49 From information received from the MoD, Ofcom has concluded that there is negligible risk of interference to MoD use of this band from new services in 2010 – 2025 MHz. The probability of Interference from MoD use to new services in 2010 – 2025 MHz is considered low but cannot be entirely ruled out.

Programme Making and Special Events (2025-2110 MHz)

5.50 Use of this band for PMSE is very similar to that described at paragraphs 5.21 above. The analysis presented there is also relevant to the 2025 MHz adjacency. Ofcom understands that the lower edge of the first 10 MHz PMSE channel starts at 2030 MHz and therefore there is an extra 5 MHz frequency separation. However, Ofcom also understands that the PMSE community may wish to re-plan the band so that the lower edge of the first PMSE channel starts at 2025 MHz. It should also be noted that airborne PMSE use is currently authorised in the band 2025 MHz – 2070 MHz.

Space research (2025-2110 MHz)

5.51 The band 2025 – 2110 MHz is allocated on a primary basis to the SPACE OPERATIONS, EARTH EXPLORATION SATELLITE and SPACE RESEARCH services all earth to space and space to space. Adjacent band compatibility between UMTS and the space science services was studied by CEPT and ERC Report 65 suggests that a 300 kHz guard band is necessary to prevent interference. This guard band is reflected in ECC Decision (06)01 which specifies that the nearest UMTS carrier to 2025 MHz should be centred on 2022.2 MHz or below. Ofcom intends to respect this by specifying that the out-of-band mask at the upper edge of the band 2010 – 2025 MHz should start 300 kHz inside the available spectrum.

5.52 The band is used in the UK for telecontrol and command links to observation satellites. Ofcom considers that respecting the CEPT guard band requirement from ECC Decision (06)01 is sufficient to protect use of the band.

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allocated. The bands should be made available for IMT-2000 in accordance with Resolution **212 (Rev.WRC-97)**. (See also Resolution **223 (WRC-2000)**.)

Earth exploration satellite (2025-2110 MHz)

5.53 See space research above.

5.54 There is no current use of the band for Earth exploration satellite in the UK and Ofcom considers that respecting the CEPT guard band requirement from ECC Decision (06)01 is sufficient to protect any international use of the band.

Implications for the 2010 MHz band award

5.55 The implications of the technical analysis are as follows.

- Ofcom is not minded to apply restrictions on the available spectrum in the 2010 MHz band in respect of PMSE use in the band above 2025 MHz. This is because filtering of PMSE equipment may be sufficient to protect both uses (PMSE receivers and receivers of new uses in the 2010 MHz band).

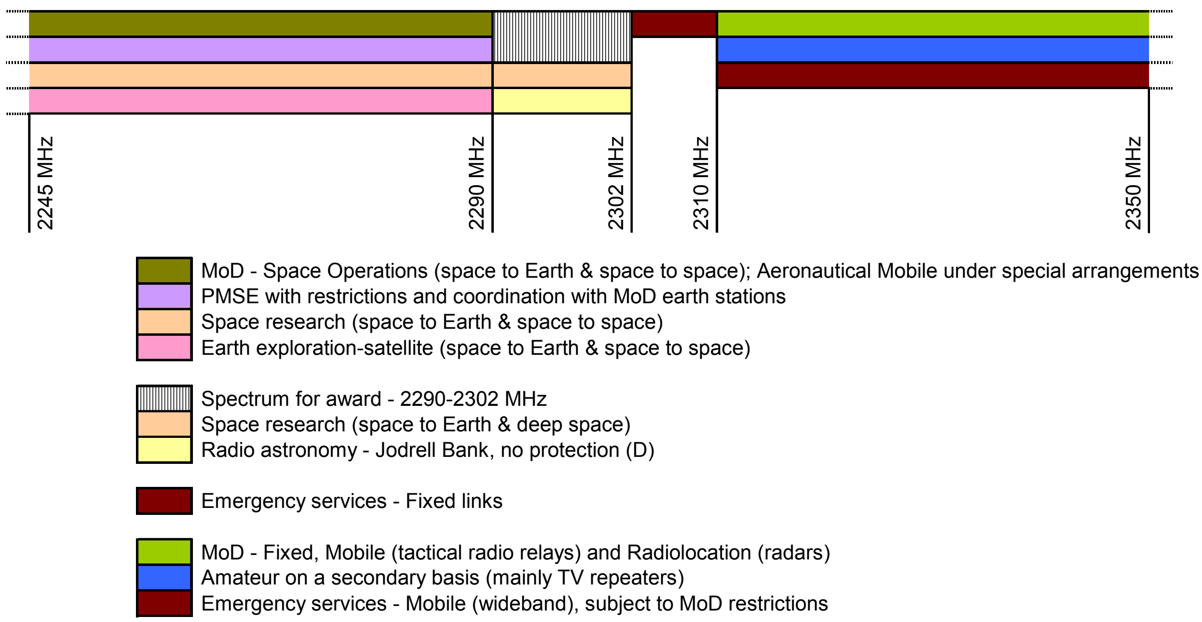
- As indicated above, Ofcom intends to respect the conclusions of ERC Report 65 by starting the out-of-band masks 500 kHz inside the 2010 MHz boundary and 300 kHz inside the 2025 MHz boundary. Ofcom's understanding is that, with relatively modest modifications, this would still allow the use of three channels for technologies normally using 5 MHz channel rasters. No other restrictions are considered necessary.

Technical analysis for 2290-2300 MHz

UK allocations and uses

5.56 The figure below illustrates the current allocations within the 2290 MHz band and is based on the UKFAT.

Figure 6: service allocations in the 2290 MHz band and adjacent spectrum



5.57 As indicated section 2 above, this band has been released by the MoD, no assignments have been made in the band and it is essentially vacant except for some localised legacy use by MoD at a station in Hampshire.

Space research

5.58 The UKFAT allocates the band 2290 – 2300 MHz to space research on a secondary basis. There is no need to place restrictions on transmissions from the 2290 MHz band to protect space research in the UK.

Radio astronomy (UK FAT class D protection)

5.59 Annex D of the UKFAT includes a reference to radio astronomy use in the band 2290 – 2300 MHz at Jodrell Bank for VLBI and pulsar observations. The protection category assigned is D (i.e. no protection). There is no need to place restrictions on transmissions from the 2290 MHz band to protect radio astronomy in the UK.

International allocations and uses

5.60 The band 2290 – 2300 MHz is allocated to the FIXED and MOBILE (except aeronautical mobile) and SPACE RESEARCH (deep space and space to Earth) services in all three ITU regions. Within the ITU RRs, the band has been identified on a world wide basis for IMT-2000.

5.61 Within Europe, use of this band varies and it has not been the subject of any European regulatory measures. It is very unlikely that any proposals for new regulation will come forward within Europe in the near future.

Uses adjacent to 2290-2302 MHz

MoD for mobile and space operations (2200-2290 MHz)

5.62 The UKFAT has the following allocations to the MoD in this band:

- 2200 – 2245 MHz – MoD for the Mobile service; and
- 2200 – 2290 MHz – MoD for the Space Operations service.

5.63 From information received from the MoD, Ofcom has concluded that there is a negligible risk of interference to the MoD use of this band from new services in 2290 – 2300 MHz. The probability of interference from MoD use to new services in 2290 – 2300 MHz is considered low but cannot be entirely ruled out.

Programme Making and Special Events (2200-2290 MHz)

5.64 Use of this band for PMSE is very similar to that described at paragraphs 5.21 to 5.24 above and that analysis presented there is also relevant to the 2290 MHz adjacency.

Space research (2200-2290 MHz)

5.65 The band 2200 – 2290 MHz is allocated on a primary basis to the SPACE OPERATIONS, EARTH EXPLORATION SATELLITE and SPACE RESEARCH services all space to Earth and space to space.

5.66 There is no current use of the band for space research in the UK and Ofcom considers that the risk of interference from new use in the 2290 – 2300 MHz band to any international use of the band is very low.

Earth Exploration Satellite (2200-2290 MHz)

5.67 See Space research above.

5.68 There is no current use of the band for Earth exploration satellite in the UK and Ofcom considers that the risk of interference from new use in the 2290 – 2300 MHz band to any international use of the band is very low.

Implications for the 2290 MHz band award

5.69 Ofcom is not minded to apply restrictions on the available spectrum in the 2290 MHz. Although PMSE use in the immediately adjacent spectrum below 2290 MHz would be likely to cause interference to, and receive interference from, new use in the 2290 MHz band, filtering of PMSE equipment may be sufficient to mitigate such interference.

Question 2: Do you agree with the analysis in section 5 or have any comments on adjacent interference issues?

Section 6

Ofcom's objectives and proposed approach to the awards

6.1 This section provides an account of Ofcom's proposed approach to the awards. It begins with a summary of Ofcom's objectives for the awards and then addresses a series of questions on authorisation, including:

a) whether to authorise use of the three available bands;

b) how to authorise use of the bands (by way of licence-exemption or licensing, and under the licensing approach, how to award licences for use of the bands i.e. by way of auction or otherwise); and

c) future authorisation decisions.

6.2 Section 6 then considers the following key questions:

a) the timing of the awards, taking into account the level of existing use, the demand for future uses of the band, the benefits that might be expected to arise from use of the bands, the balance of costs and benefits of a potential delay in release of the bands (e.g. for reasons connected with the availability of information on other spectrum bands) and the potential for further European harmonisation decisions affecting these bands;

b) the degree of flexibility in allocation of spectrum to different types of technology;

c) what the main non-technical licence conditions should be (relating to the position on technology and service neutrality, tenure, tradability and absence of rollout obligations);

d) potential consequences from Ofcom's proposals for non-technical licence conditions (such as tenure and absence of roll-out obligations) or timing of award; and

e) whether there should be any restriction on the amount of spectrum that individual bidders could obtain through the award.

6.3 In discussing the general approach, we consider relevant points raised by respondents to the SFR:IP in relation to the 2.6 GHz and 2010 MHz bands in particular.

Objectives for the awards

6.4 The main objective of this award of wireless telegraphy licences is to promote the optimal use of the electro-magnetic spectrum, particularly in the 2.6 GHz, 2010 MHz and 2290 MHz bands in line with Ofcom's duties. In preparing the proposals designed to secure that objective, Ofcom has had regard, in particular, to the availability of, and demand for, spectrum and to the desirability of promoting:

a) the efficient management and use of the spectrum;

b) the economic and other benefits that may arise from use of the spectrum;

c) the development of innovative services; and

d) competition in the provision of electronic communications services.

6.5 The SFR Statement identifies the use of auctions as the most appropriate means to distribute spectrum that is not currently assigned where demand for the spectrum is likely to exceed supply. It also sets out the view that spectrum should be auctioned in a technology and usage neutral way. We have followed this approach in framing the proposals for the award of this band.

Authorising use of the three bands

6.6 The three bands are either free of incumbent users or will soon be free of incumbent users. It is therefore relevant to consider whether the bands should be made available for new uses.

6.7 Ofcom is not aware of any reasons why the spectrum bands should not be made available for use. On the contrary, Ofcom considers that there are particularly good reasons for making the bands available and that doing so would be consistent with its duties under the 2003 Act.

- It is likely to further the interests of citizens and consumers, by creating opportunities for increased competition and the development of new services.
- Making the bands available is also likely to promote optimal use of the electro-magnetic spectrum, by allowing use of the resource that would otherwise lie fallow.
- Optimal use will also be promoted because these bands may be more useful to potential users than spectrum available in other existing bands, for example because of the physical propagation characteristics of their frequencies.
- On the basis of available evidence, the strong demand for the provision of wireless services using the bands (see paragraphs 6.30 to 6.39), in particular the 2.6 GHz band, suggests that an award would stimulate investment and innovation by removing a barrier to entry, spectrum being a necessary input to the development of wireless services.
- Potential new and innovative services would contribute to expand the range of available services in the UK.
- An award may also further the availability of broadband services in the UK.

6.8 Therefore, Ofcom believes that the evidence strongly points to the conclusion that it should authorise use of the three bands.

Question 3: Do you agree that Ofcom should authorise use of the spectrum bands 2500-2690 MHz, 2010-2025 MHz and 2290-2300 MHz?

Choice of authorisation mechanism

6.9 The paragraphs below consider the most appropriate method for authorising use of the available bands.

Licence exemption

6.10 As noted in the SFR:IP and elsewhere, Ofcom has a duty (in section 1AA of the Wireless Telegraphy Act 1949) to make regulations exempting the use of any particular apparatus from licensing if it is satisfied that the use of such apparatus for wireless telegraphy is not likely to involve any undue interference with wireless telegraphy. Ofcom has considered whether use of apparatus in the 2.6 GHz, 2010 MHz and 2290 MHz bands would be suitable for licence exemption.

6.11 The market assessment has revealed a wide range of potential uses of these bands, including mobile telephony, mobile multimedia, broadband wireless access and PMSE. Deployment of most of these potential uses on a licence-exempt basis would be likely to result in significant interference, as most of these uses employ transmitters that require operation at significant power levels, and as a result would create large zones of potential interference. Ofcom is not aware of any plans for use of any of the three bands under a licence-exempt regime. Further, in the case of the 2010 MHz band, the spectrum has been set aside since 2000 for potential licence-exempt use for self-provided self-coordinating IMT-2000 systems and this has not resulted in any use.

6.12 Ofcom therefore considers that a licence-exempt approach would not be conducive to optimal use of the 2.6 GHz, 2010 MHz and 2290 MHz bands as it would be likely to give rise to harmful interference and would be unlikely to yield benefits that could not be better achieved via a licensing approach.

Award through auctions

6.13 Ofcom has considered what kind of mechanism for award of the spectrum bands is likely to result in the most efficient outcome for the use of the spectrum. Ofcom set out its general view in the SFR:IP Interim Statement (see paragraphs 3.3 to 3.8) and in the SFR Statement that an auction mechanism is likely to be Ofcom’s preferred tool for assigning licences to use unused spectrum, where demand for the licences is likely to exceed supply. Having considered the particular circumstances of the three spectrum bands, Ofcom has concluded that auction mechanisms should be preferred.

6.14 Ofcom considers that auctions generally offer the most open, transparent and non-discriminatory method out of those available for determining who should be granted licences for the available bands. This is because in auctions, a bidding process is used to award licences to those bidders prepared to pay most for them. Auctions are therefore likely to lead to the spectrum rights being assigned to users that value them most highly, which will generally be those who are likely to use the spectrum most efficiently. By contrast, in Ofcom’s view, other assignment mechanisms are unlikely to be as effective in promoting optimal use of the spectrum for these bands. Alternative assignment mechanisms include first come first served processes, where licences are assigned to applicants in the order of their application, and comparative selection processes, where licences are assigned to the applicants that, in the regulator’s judgement, best satisfy the selection criteria that it has set. A first come first served process would not be appropriate where demand for spectrum is likely to exceed supply - the first applicants may not be those who would make the optimal use of the spectrum and many applicants may come forward at the same time. A comparative selection process involves defining selection criteria and assessing candidates' submissions and so carries the risk of subjective judgements being made which may result in the spectrum not being awarded to the bidders who are able to use it to maximum advantage.

6.15 Ofcom considers that this reasoning is relevant to the 2.6 GHz, 2010 MHz and 2290 MHz bands as it is to a number of other bands. Moreover, Ofcom considers that the evidence available suggests there is significant interest in acquiring rights to use spectrum in these bands, and that it is likely that demand will exceed supply. Well-designed auction processes, including appropriate designs of licence conditions and packaging, should give maximum flexibility for the market to determine the use of the spectrum bands and the identity of the users. This will further reduce the risk of regulatory error and unnecessary intervention in assigning rights to use these spectrum bands.

6.16 Ofcom has considered whether there are any potential sources of market failure that could mean that the use of an auction to award the spectrum would not be the preferred mechanism to promote the interests of citizens and consumers. Ofcom has not identified to date any significant concerns in relation to potential market failure that would call into question the use of an auction as the mechanism to award the spectrum in these specific bands (or which would indicate a possible need to take steps through auction design to promote or discourage particular outcomes).

6.17 Ofcom therefore considers that the three spectrum bands should be awarded by way of auction. Ofcom's proposal to use auctions as the method for assignment, and Ofcom's other proposals relating to the details of the auction design, are derived from the objectives for the awards, and in particular the aim of securing optimal use of the spectrum. It is not Ofcom's objective to raise revenue by means of spectrum auctions nor, given Ofcom's statutory duties, is this a matter that Ofcom takes into account.

6.18 Section 7 (on spectrum packaging) and section 8 (on auctions sequence, formats and rules) set out Ofcom's detailed proposals for the design of the auction process for the spectrum bands.

Question 4: Do you agree that awarding licences by auction would be the appropriate mechanism for authorising use of the spectrum bands 2500-2690 MHz, 2010-2025 MHz and 2290-2300 MHz?

Future authorisation decisions

6.19 Ofcom is not proposing to place any limitation as a function of the proposed award processes on the scope for it to license other providers to use spectrum to offer services that could compete with those that may be offered using the available spectrum bands. Such licensing may occur by means of the award of new licences to use spectrum in other bands, by means of decisions as to licence exemptions or via the removal of restrictions on the use of bands that have already been licensed.

6.20 In the future there may be reasons to consider allowing licence exempt use of the available spectrum bands in conjunction with the licensed use proposed in this document. For example, it is likely that use of UWB equipment will be authorised in the UK in future, as a result of a decision of the RSC or otherwise (see paragraphs 4.51 to 4.53). This can be expected to result in licence-exempt use and emissions in the three available bands. Subject to the provisions of international obligations, Ofcom would consult stakeholders on its plans, as part of its assessment of the case for such authorisation.

6.21 It is also possible that Ofcom may be required to take other authorisation decisions for licensed use or licence-exempt use in order to comply with international obligations that do not presently exist and are not identified as potential future measures at this stage. In principle, Ofcom may also use its discretion to assign additional wireless telegraphy licences for use of the three spectrum bands either of the same character or of a different character to those described in these proposals. At this time, Ofcom is not aware of any reason to consider authorising additional wireless telegraphy use of the three spectrum bands following an award and the potential introduction of UWB equipment in the UK. In future, if it were to consider any further assignments, Ofcom would consult stakeholders on possible plans.

Timing of awards

6.22 Given Ofcom's proposal to award licences for use of the three bands, it is relevant to consider when those awards should take place.

6.23 Although a number of considerations are relevant to all three bands, the following discussion focuses on the 2.6 GHz band which represents the largest amount of spectrum to be awarded (total of 190 MHz available as opposed to 15 MHz for the 2010 MHz band and 10 MHz for the 2290 MHz band).

6.24 On balance, Ofcom believes that it would be beneficial, and in keeping with the objectives set out above, to award the bands as soon as practical for the following reasons.

a) The spectrum for award will be unused or underused from 1 January 2007.

b) There is likely to be considerable demand for the spectrum for a range of possible uses. In responses to the SFR:IP and as part of the independent market research exercise, some of the potential users indicated that they are seeking access to the spectrum as soon as possible, in particular for the 2.6 GHz band.

c) By allowing the spectrum to be used for the range of possible uses identified, the award is likely to create significant benefits for consumers and the economy at large. Value would be created through providing potentially innovative new services, competition benefits and cost savings.

d) Delaying the award of the spectrum would lead to those benefits being forgone during the period of delay. The loss of these benefits is likely to be more material then the potential benefits that delay might bring (e.g. in terms of further information on the availability of other spectrum).

6.25 These factors are considered in turn in the paragraphs below, following which we present Ofcom's proposal with respect to timing of award for the three bands.

The bands will be unused or underused from 1 January 2007

6.26 The 2010 MHz band has been unused in the UK since it was made available for licence-exempt IMT-2000 TDD use, following the adoption by CEPT of ERC Decision (99)25.

6.27 The 2290 MHz band has also been unused, except for some localised legacy use by MoD at a station in Hampshire, since MoD transferred the band to Ofcom in 2004.

6.28 The 2.6 GHz band is currently licensed to users for programme making and special events (wireless cameras and video links), authorised until the end of 2006. They were notified in 2002 by the Radiocommunications Agency that they would have to vacate the band by then. It was recognised at the time that the pattern of spectrum use by PMSE operators, being largely concentrated in dense urban environments, was compatible with other uses that do not take place in similar areas. The Radiocommunications Agency therefore took the decision to relocate PMSE use from the band 2500-2690 MHz to the bands 2025-2110 MHz and 2200-2290 MHz, where terrestrial use is limited to MoD operations which tend to take place in less dense environments. When it became apparent that the award of the 2.6 GHz band may not take place by early 2007, Ofcom decided to facilitate the decommissioning of the PMSE licensees' use, by allowing an extension to their tenure. Those users will from 1 January 2007 hold annual licences revocable on 3 months' notice. From then, Ofcom expects their use to be of a transitional nature, gradually decreasing and very limited compared to the amount of spectrum available. The 2.6 GHz band will therefore be available for new uses from any date within 2007, subject to three months' notice, and will likely be used with less intensity until those new uses can develop.

6.29 In a context where significant potential demand has been identified, Ofcom considers that minimising the period during which spectrum remains underused or unused is likely to secure optimal use of the spectrum. This is an important reason for proceeding with the awards as soon as practicable.

Demand for the bands and potential uses

6.30 Ofcom has received evidence of significant potential demand for use of these bands from a number of sources including:

- responses to various consultations, including the SFR:IP, the EC consultation on the 2.6 GHz band and the work relating to the ECC Decision on the 2.6 GHz and 2010 MHz bands;
- the market research carried out by the Consultants in preparation for this consultation in which they engaged with a wide range of industry stakeholders; and
- the investments made by industry in developing standards and proprietary technologies specifically relevant to these bands.

6.31 The extent of the potential demand for spectrum appears to be such that it is likely to exceed the supply across the three bands.

6.32 A number of respondents to the SFR:IP expressed interest in the three bands and particularly the 2.6 GHz band. Some, such as BT, Intellect, IEEE 802, Kingston Communications, Nomad, the WiMAX Forum, were very specific in arguing that the 2.6 GHz band should be made available at the earliest opportunity or that Ofcom should carry out the award as proposed in the SFR:IP, i.e. in the financial year 2006/07.

6.33 In June 2005, the European Commission invited comments on the potential harmonisation of the 2.6 GHz band. Out of the 59 responses it received, a number expressed a high degree of interest in the bands from equipment manufacturers, operators and industry groups across Europe. In the consideration of the specific questions set by the EC, respondents such as Alvarion, AT&T, BT Group, Ericsson, Nokia, Nortel, WiMAX Forum, the Wireless Communications Association and various MNOs all suggested a strong market interest in the 2.6 GHz band. This interest was underpinned by the development of a range of technologies (IMT-2000 and others) to use the band as well as potential plans to develop services using that spectrum as soon as it would become available. Document RSCOM05-44rev1[69] provides a summary of the responses to the consultation on the specific points raised by the EC.

6.34 Also at the international level, the two relevant ECC Decisions identify particular dates for making the 2.6 GHz band and the 2010 MHz band available. Both decisions were the subject of public consultations in 2005 and involved input from industry stakeholders at large, including inputs on the issue of when the bands should be made available. ECC Decision (05)05 identifies 1 January 2008 as the date by which the 2.6 GHz band should generally be available for use and ECC Decision (06)01 identifies 1 October 2006 as the date by which the 2010 MHz band should generally be available for use. This suggests that making the bands available before 2008 is seen as relevant to market conditions across a majority of CEPT countries and that it has been anticipated for some time at an international level that demand for the bands would materialise before 2008.

6.35 In their work for Ofcom, the Consultants also identified strong demand for use of the available bands as part of their market research and interviews. They reported significant demand for the 2.6 GHz band, and to a lesser extent the 2010 MHz band, to provide mobile telephony and data services, mobile multimedia services and broadband wireless services as summarised at paragraphs 2.46. The research also suggested that companies other than existing MNOs or existing fixed broadband wireless providers had a potential interest in using the bands. These views on high demand and the potential for new providers were confirmed by an assessment of the likely costs and revenues associated with the provision of services in those bands. The information available to Ofcom suggests that there would be excess demand for the 2.6 GHz and 2010 MHz bands from 2008, even under conservative assumptions regarding the development of user demand for potential services. It is possible that a number of operators not currently providing wireless services in the UK could gain access to the spectrum. For those potential new operators, early certainty concerning their access to spectrum, and therefore an early award, is particularly important to allow them to achieve necessary agreements with commercial partners such as equipment providers.

6.36 PMSE users, which currently operate in the 2.6 GHz band and in the band adjacent to the 2010 MHz band, may also have a demand for those frequencies. They could use them from completion of an award in the case of the 2.6 GHz band, as equipment already exists, or soon after in the case of the 2010 MHz band, as Ofcom understands that adapting equipment designed for adjacent frequencies would be a relatively modest task. The Consultants considered that PMSE users were likely to have a preference for the 2290 MHz band as they perceived that their chances of gaining access to this band, as opposed to the other two bands, were likely to be greater in a competitive award process. Again, it is expected that equipment used by PMSE in the adjacent band could be adapted for relatively rapid deployment at 2290 MHz.

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[69] See http://forum.europa.eu.int/Public/irc/infso/radiospectrum/library?l=/public_documents_2005/rsc13_october_2005/rscom05-44rev1_imt-2000p/_EN_1.0_&a=d.

6.37 The importance of the 2.6 GHz and 2010 MHz bands is also illustrated by industry investment in the development of standards and proprietary technologies specifically relevant to these bands. These include standards for UMTS and its evolutions developed by industry group 3GPP[70], involving several hundreds of members from Europe, America and Asia such as manufacturers and operators. 3GPP has included the 2.6 GHz band within its specifications from 2005 and European standardisation body ETSI[71] included the band within European harmonised standards under the RTTE Directive for IMT-2000 from 2006. The US standardisation body IEEE[72] has also been developing standards relevant to the 2.6 GHz band, involving similarly large numbers of important stakeholders from the wireless industry. The IEEE 802.16 group has produced two standards and technical specifications for broadband wireless technologies often referred to as WiMAX. The latest version of the IEEE 802.16 standard is known as 802.16-e of 2005 and covers both fixed and mobile variants of the technology. In addition ETSI is also developing a European harmonised standard under the RTTE Directive for broadband wireless access of the 2.6 GHz band. A number of other technologies are also available and largely ready for deployment in the 2.6 GHz and/or 2010 MHz band following significant investment from their proponents. These include HC-SDMA, standardised by ANSI; proprietary Flash-OFDM; MBMS and TDtv, standardised by 3GPP, and the work of the IEEE 802.20 group (technical specification adopted for FDD and TDD and standard being progressed).

6.38 In response to these technology developments, several stakeholders have recently announced their commitment to new technologies designed to be used in the 2.6 GHz band. Some examples of corresponding press releases came from:

a) operators in large mature markets

- in July and September 2006, US operator Clearwire reported large investments from Motorola and Intel to develop WiMAX offerings[73]; and
- US operator Sprint Nextel stated its commitment to invest significantly in the development of a WiMAX network using the 2.6 GHz band, in partnership with Motorola, Intel and Samsung, by the end of 2008[74]; and

b) important manufacturers active in markets worldwide

- in October 2006, Nokia reported the planned commercial availability, for the 2.6 GHz band, of WiMAX base stations at the end of 2007 and of WiMAX-capable mobile devices in 2008[75]; and
- in October 2006, Nortel announced the introduction of a WiMAX equipment portfolio based on specific developments of WiMAX technologies[76].

6.39 These are just a few recent examples. Other manufacturers who are part of standardisation groups or creators of proprietary technologies have developed

[70] See http://www.3gpp.org/.
[71] See http://www.etsi.org/.
[72] See http://www.ieee.org.
[73] See press releases of 5 July 2006 (http://www.clearwire.com/company/news/07_05_06.php) and 6 September 2006 (http://www.clearwire.com/company/news/09_06_06.php).
[74] See press release of 8 August 2006 (http://www2.sprint.com/mr/news_dtl.do?id=12960).
[75] See press release of 11 October 2006 (http://www.nokia.com/A4136001?newsid=1080626).
[76] See press release of 10 October 2006 (http://www2.nortel.com/go/news_detail.jsp?cat_id=-8055&oid=100206953&locale=en-US).

various offerings of direct relevance to these bands or stated commitments to do so[77].

Competition and innovation benefits, cost savings

6.40 Ofcom believes that making the 2.6 GHz and 2010 MHz bands, in particular, available on a technology neutral basis is likely to realise significant economic welfare gains, including significant benefits for consumers.

6.41 The potential sources of the increase in welfare relate to the following.

a) New entry into the relevant downstream markets using the spectrum to offer services in competition with the existing operators providing mobile voice and data services or broadband wireless access and reduced barriers to expansion. This increase in competition could result in a reduction in operator prices and an increase in demand for services, as well as greater consumer choice for services.

b) Gains from innovation where operators are able to offer new or improved advanced telephony or broadband wireless services, which might not otherwise be possible, at least in the near term. This possibility is highlighted when comparing spectrum availability in the UK with the bands for which some technologies put forward by stakeholders are designed. One example is the version of WiMAX for mobile use, which has currently been developed for operations in the 2.3 GHz and 2.6 GHz bands (as these are the bands which are seen as becoming available internationally for mobile use and have sufficient spectrum available to support advanced data services). However, in the UK the 2.6 GHz band is potentially the only band where mobile WiMAX could be used with certainty in the UK for the foreseeable future[78].

c) Cost reductions that existing operators, in particular the 5 MNOs, could achieve by having access to more frequencies. This would enable them to increase capacity more efficiently where necessary, using transmitter sites which are already in service rather than having to pursue the more expensive option of searching for and developing new sites. To the extent that the resulting savings affect marginal costs, and to the extent that the downstream markets are competitive, then these cost savings are likely to be passed on to consumers.

6.42 Ofcom has carried out an assessment of the order of magnitude of benefits that could arise from making these bands available for the provision of mobile telephony and wireless broadband services. The largest source of benefit could come from innovation, although the estimation of the size of the potential innovation benefits is, by its nature, subject to considerable uncertainty. However, the likely scale of these benefits is illustrated by that of relevant downstream markets, such as those associated with the provisions of mobile telephony services and with the provision of broadband services, which are very large in size. The benefits of increased competition and reduced costs are also expected to be very material.

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[77] See the list of relevant technologies at Annex 7 and other press releases for example by Alcatel (4 October 2006, http://www.home.alcatel.com/vpr/vpr.nsf/AllDocuments/A287A45E2EA22510C12571FD0041D311?openDocument) or Fujitsu (18 October 2006, http://www.fujitsu.com/sg/news/pr/fmal_20061018.html).

[78] In UK the 2.3 GHz band (2300-2400 MHz) is used by MoD and other users and is not available for national mobile network deployments. The only exception is the band 2300-2310 MHz which may become available in the future (see paragraph 2.68). However, even if this block of 10 MHz does become available, the market interviews indicate that WiMAX deployments would be likely to require more bandwidth than 10 MHz.

Balance of costs and benefits of a potential delay of an award

6.43 A number of supplementary questions are relevant when considering the potential consequences of a delay in award of the 2.6 GHz and associated bands. These relate to:

- the potential costs of a delay where these relate to the benefits forgone through not bringing the bands into use at the earliest opportunity; and
- the potential benefit in delay in order to wait for better information on the position regarding potential substitute spectrum on the basis that better information could lead to a more efficient outcome for the awards and, hence, more efficient use of the spectrum.

Potential costs of delaying the awards

6.44 An implication of Ofcom's assessment of the potential size of benefits from releasing these bands is that a delay of the award would be likely to lead to significant losses in economic benefits, including losses in consumer welfare. This is, in part, because the benefits that could otherwise be created by use of the spectrum during the period of the delay would simply be lost.

6.45 In relation to the possible competition and innovation benefits, in particular those which might be realised through the deployment of WiMAX or similar new technologies (e.g. HC-SDMA or MB TDD/IEEE 802.20), it should be noted that unless and until the 2.6 GHz band is released, there will be some technologies that operators might wish to deploy which cannot be deployed in the UK at present (see paragraph 6.41 above). Therefore the possibility of realising the welfare gains from services using these technologies depends, at least to a large extent, on the release of those spectrum bands. While of course the release of the bands does not guarantee the benefits will occur, not releasing the spectrum would remove that possibility. Delaying the release would delay the chance of the benefits being released and affect the size of those benefits. Accordingly, the costs of delay could be significant.

6.46 The potential dynamic effects of making spectrum available for new technologies within Europe are also relevant. At this stage, it is not clear whether or when other European countries could make the 2.6 GHz or 2010 MHz available for new broadband wireless technologies such as WiMAX as well as existing technologies. There is a risk that the opportunity for some new technologies to access spectrum in Europe may be reduced, or that their implementation and development cycle may be restricted, if spectrum is not available at the right time. The scope for accessing spectrum is an input to the manufacturers' and operators' considerations on the development of equipment and services. If there are not opportunities for those new technologies to access spectrum in an important region like Europe, which can have an important impact on their ability to achieve economies of scale, their growth and emergence could be limited or delayed. Now that standards are in place and equipment is being developed for the candidate new technologies identified, it is likely that Europe is at a critical stage in this respect.

6.47 Delaying the award of the 2.6 GHz band would also restrict the number of technologies for 3G/advanced wireless services to the UMTS technology (in the core bands), forcing consumers who wish to access such services to use services based on UMTS. This would create further barriers to innovation and the development of competition between different platforms for mobile services. Even if new technologies could access spectrum later, entry would be more difficult because of obstacles to consumers changing providers when they decided to use available services during the period of delay. Such obstacles include the costs of replacing handsets, changing numbers or learning to use new services.

6.48 The above considerations indicate that there could be substantial costs, or forgone benefits, from a delay in making the spectrum available as soon as practicable.

Potential benefits of delay in terms of information on availability of other spectrum

6.49 Ofcom has considered the extent to which there might be benefits in delaying the awards in order to wait for more information on potential substitute spectrum to become available to interested parties. The benefit of greater information is that it might allow interested parties to make better decisions regarding their possible participation in the award of the 2.6 GHz and 2010 MHz bands and might, thereby, increase the efficiency of the awards.

6.50 Some respondents to the SFR:IP, Lucent and some MNOs in particular, argued that an award of the 2.6 GHz band was highly likely to be inefficient unless it was clarified whether and how the current holdings of 2G spectrum at 900 and 1800 MHz could be used with technologies other than GSM. Some MNOs considered that they would not be in a position to properly assess their demand for spectrum at 2.6 GHz if the award were to take place at a time when it was not clear to them whether they could develop the services they would envisage providing in the 2.6 GHz band by using mobile telephony technologies other than GSM in their current holdings at 900 MHz and 1800 MHz.

6.51 Two MNOs also considered that the potential availability of spectrum in the UHF band (470-862 MHz), as a result of the switchover to digital terrestrial television, would need to be clarified before an award of the 2.6 GHz band could efficiently take place. For similar reasons, they suggested that their ability to identify the amount of spectrum they could require and the value they could attach to those frequencies in the 2.6 GHz band was dependent on knowing whether and how frequencies in the band 470-862 MHz would become available. This was because the band 470-862 MHz could potentially be used for the provision of services similar to those that could be developed at 2.6 GHz.

6.52 Similar points of principle regarding the desirability of making information available so far as possible were raised in an academic paper submitted alongside O2's response to the SFR:IP.

6.53 Ofcom has considered carefully the relevance of information about other spectrum bands that could be a potential alternative to use of the 2.6GHz band, and in particular the suggestion that it should eliminate uncertainty in relation to the future use of these bands before it proceeds with the award of the 2.6GHz band.

6.54 Ofcom considers that as a general principle it is desirable to have as much relevant information available about other bands as is possible at the time of any spectrum award. The question is whether it is appropriate to delay an award against the possibility that additional information becomes available in order to improve the efficiency of the award process. In order to judge this, it is important to understand the range of sources of uncertainty for potential users of the spectrum, to consider whether uncertainty can be reduced and if so how, and then to balance the potential benefits of any reduction in uncertainty against any adverse effects, such as the consequences of delay.

6.55 As discussed in Section 2, there is a wide range of alternative bands that could be used to supply services similar to those that could be provided using the bands that are the subject of this consultation. This range includes:

- bands that are already included within Ofcom's awards programme, as set out in the SFR:IP, and amended from time to time;
- bands that may be released in future, either by Ofcom or by public sector users; and
- bands that have already been licensed and that are currently in use.

6.56 More detail is included on many bands that could be relevant below. However, it is important to recognise that this is unlikely to be a comprehensive list of potential alternatives. Ofcom's strategy for spectrum management, as set out in the SFR and other documents, is based on allowing much greater flexibility in how spectrum is used than hitherto, and encouraging the efficient use of spectrum through the application of market mechanisms.

6.57 It is probable that, as this strategy is extended, an increasingly wide range of bands will become potential substitutes for each other. This is desirable from the perspective of citizens and consumers in terms of optimal use of the spectrum, as it will increase the supply of frequencies that is available for uses that are most valuable to society. It does however have the consequence that potential users of spectrum will need to consider an increasingly wide range of options, and to the extent that those options may be more or less complex, they will need to take that complexity into account.

6.58 It is also important to note that while different spectrum bands may become increasingly substitutable over time as regulation diminishes, there are almost invariably particular characteristics or features that distinguish one band from another. The sources of these differences are many. The most basic is fundamental differences in technical characteristics, such as propagation, which mean that some bands are more suitable for some activities than others. It is generally accepted, for example, that lower frequencies below 1GHz offer better coverage than higher frequencies, allowing lower cost coverage of large areas, and perhaps also improved coverage in buildings.

6.59 Other differences between bands that can be material include: the amount of spectrum available in any band; the nature of neighbouring uses; prospective changes in technology, which can affect the relative suitability of different bands; the current and future regulatory position in relation to a band, both within the UK and internationally; the international commercial position, such as the cost and suitability of equipment that may be made for a particular band in other markets; the likely timing of availability; and the likely cost of different bands, relative both to each other and to other inputs such as network equipment. The cost of a band may of course itself be affected by many other factors, such as the level of demand for a band from other potential users, and the likely development of consumer demand for a multiplicity of potential wireless products and services.

6.60 This is no more than a summary analysis, but it can be seen that the extent to which one band may be an alternative to another can depend on a wide array of factors. Many of these factors are themselves subject to uncertainty and change, and different potential users of any spectrum band may make different assessments of the weight to be attached to different factors.

6.61 Bands that Ofcom is already considering for release to the market, which could be used for services similar to those that could be supported by bands that are the subject of this consultation, include: frequencies in the band 470-862 MHz; 1452-1492 MHz; 1785-1805 MHz (available in Northern Ireland); 1790-1798 MHz (in Great Britain); 2302-2310 MHz; spectrum in the 3.6-4.2 GHz band.

6.62 The latest information available in relation to each of these bands can be found on the Ofcom website. It will be evident from a study of the relevant documents that there is significant uncertainty in relation to many aspects of the future of these bands. Considering only international regulatory issues, for example, this uncertainty includes the potential for international regulatory measures at EU and/or ITU level affecting two key bands:

- 470-862MHz. On this band, there is work under way in CEPT under Mandate from the European Commission, it is possible that there will be Commission proposals for further action in relation to the digital dividend, and it is possible that there will be changes to ITU-RR at WRC-07 or WRC-10; and

- 1452-1492MHz. On this band, there is work under way in CEPT under Mandate from the European Commission, it is possible that there will be Commission proposals for further action by way of an RSC Decision, and it is also possible that there will be bilateral and multilateral discussions among administrations that are party to the Maastricht Arrangement.

6.63 Other spectrum bands may also become available for commercial use as a result of the programme of work that is following on from the Independent Audit of Spectrum Holdings, which was concluded in December 2005[79]. The Government responded to the Audit, accepting its recommendations and committing to an implementation plan that is likely to lead to spectrum releases in the coming years[80]. Government departments are expected to identify key bands where the conclusions of the audit could be implemented by means of release and to outline specific proposals for actions in these bands.

6.64 An update on progress in implementation was published by the Government on 6 December 2006[81]. This noted work that is in under way in relation to the sharing of bands that are used for civil and military radars, which could result in increased commercial access. Some of these bands are in fact almost adjacent to the bands that are the subject of this consultation. There is however inevitably uncertainty about the nature, timing and terms of any commercial access that might be feasible. It is expected that proposals for further implementation will be outlined in a Government "forward look" document expected to be published in spring 2007.

6.65 Other spectrum bands are currently licensed and in use, which may be suitable for the provision of services that could also be provided using the 2.6 GHz, 2010 MHz and 2290 MHz bands. Some examples of such bands include:

a) the 900 MHz (880-915 MHz paired with 925-960 MHz) and 1800 MHz (1710-1785 MHz paired with 1805-1880 MHz) bands currently licensed for GSM technology (also referred to as 2G) and being considered in international fora for other technologies such as UMTS/IMT-2000;

[79] The report is available at http://www.spectrumaudit.org.uk/final.htm.
[80] The Government's response is available at http://www.spectrumaudit.org.uk/220306.htm.
[81] http://www.spectrumaudit.org.uk/pdf/cave_progress_rpt.pdf

b) the 2.1 GHz band (1920-1980 MHz paired with 2110-2170 MHz and 1900-1920 MHz) currently licensed for UMTS technology (also referred to as 3G and part of the IMT-2000 family);

c) spectrum in the 3.4 GHz band (3480-3500 MHz paired with 3580-3600 MHz) currently licensed for fixed wireless access (provision of wireless services at fixed locations) and the 3.6 GHz band (3605-3689 MHz paired with 3925-4009 MHz) licensed for fixed wireless access as well and shared with satellite services; and

d) the 450-470 MHz band, currently licensed for various business radio uses (private communications services for businesses).

6.66 Each of these bands is also typically subject to a further range of factors that is particular to that band, and that may affect the nature, timing, and terms of its availability for alternative uses.

6.67 This includes in particular the international regulatory framework. Many of these bands have been the subject of past international regulation and/or are the potential subject of further international regulation. For example, in relation to the 900MHz band, the European Directive 87/372/EEC (the "GSM Directive") restricts the use of most frequencies in the band to GSM technology. The use of this band for other technologies is therefore dependent on further regulatory decisions involving the European Parliament, Council and Commission. Ofcom is able to contribute to the debate at European level on these matters, but it is not able to determine the outcome.

6.68 There are therefore many sources of uncertainty in relation to alternative bands that could be used to supply services similar to those that are the subject of this consultation. To the extent that Ofcom can itself reduce such uncertainty prior to the award of a spectrum band, it considers that it should seek to do so wherever this is feasible. However, it is important to recognise that reducing, let alone eliminating, uncertainty may not always be feasible; that businesses can face many more important sources of uncertainty than those that Ofcom is itself able to influence; and that uncertainty, including regulatory uncertainty, is inherent in the communications sector.

6.69 Ofcom has indeed already taken many actions to reduce regulatory uncertainty in relation to the future use of spectrum. In particular, Ofcom has already made clear its framework for spectrum policy for the purpose of fulfilling its statutory duties. With the publication of the SFR statement in June 2005 and the publication of the SFR:IP consultation and interim statement in January and July 2005, Ofcom identified the main components of this policy, which are:

- to remove restrictions on the conditions of spectrum use where it is possible to do so;
- to allow spectrum trading where possible; and
- to release underused or unused spectrum to the market where possible.

6.70 More specifically in relation to the existing 2G spectrum (at 900 MHz and 1800 MHz), Ofcom's stated spectrum management policy provides a clear indication of the general policy framework that Ofcom is seeking to implement. By gradually introducing or proposing to introduce trading and liberalisation to specific licence categories[82], particularly for commercial users, Ofcom has given specific examples of the way that the principles of Ofcom's spectrum policy may gradually be implemented.

6.71 In the SFR:IP, Ofcom considered in some detail how and when such changes might be introduced to the mobile sector, and at paragraphs 9.45 to 9.62, Ofcom set out a number of options for the liberalisation of 2G spectrum. Ofcom also addressed in the SFR:IP[83] other complex issues such as the potential liberalisation of existing licences for spectrum at 3.4 GHz and 3.6 GHz.

6.72 Moreover, Ofcom expects to take further actions that should have the effect of reducing uncertainty before it awards the bands that are the subject of this consultation. For example, Ofcom expects to consult shortly on the Digital Dividend Review, which is considering the future of spectrum in the range 470-862MHz that will be released as a consequence of digital switchover. Ofcom also expects to issue a further consultation document in relation to application of trading and liberalisation to the mobile sector, in the early part of 2007.

6.73 However, the principal reason for seeking to progress these and other matters must be to pursue the interests of citizens and consumers in relation to these issues in their own right, not to reduce uncertainty in relation to the value of spectrum that it the subject of this consultation. It may indeed be neither feasible nor appropriate to reduce uncertainty beyond a certain point.

6.74 Ofcom will however be able to make all relevant information that is available to it, as regulator, available to all potential bidders for these bands in a transparent and non-discriminatory way, through publication of a statement on this consultation, an Information Memorandum and associated regulations for consultation.

6.75 The underlying judgement to be made on whether a delay in award would be beneficial or not depends on:

- whether the information available on substitute spectrum at the time of an early award is likely to be sufficient to allow bidders to make reasonable assessments of their requirements and, if there are areas of uncertainty, how material an impact these might have on the efficiency of the award (measured against the outcome that could be expected in the absence of such uncertainty);
- whether, even if there were to be material uncertainty at the time of the award, a delay in award would materially increase the degree of certainty in relation to this information (or, put another way, how long a delay might be needed in order to allow for a material increase in certainty); and
- how the gain in efficiency of the award from this increase in certainty might compare to the benefits that would be forgone by delaying the award.

6.76 Ofcom's current judgement is as follows.

[82] The Liberalisation Statement of 26 January 2005 gave effect to initial liberalisation measures in the Business Radio, Fixed Wireless Access and Fixed Links sectors, for individual licence variation. The consultation on trading and liberalisation for business radio licensing of 06 July 2007 (available at http://www.ofcom.org.uk/consult/condocs/brtrading/) provides a further example of the implementation of Ofcom's liberalisation for this sector, this time generically for the business radio licence class.
[83] See section 8 of the SFR:IP.

- There is already a reasonable degree of information available on potential substitute spectrum and Ofcom expects to issue further information over the next year. For example, Ofcom intends to issue consultations on 2G liberalisation and DDR spectrum.

- The key issue in terms of efficiency of award outcome is for the information to be available equally to all interested parties. To the extent that they have access to the same regulatory information, the potential extent of distortions between bidders in an award as a direct function of the regulator's actions will be limited.

- It is unrealistic to assume that there will be a point of time in the future when all uncertainties may be removed. Regulatory uncertainty is inherent to regulation of a fast changing sector such as the communications sector and may be modest compared to other sources of uncertainty in an award such as the uncertainty on the levels of demand from users for particular services and their evolution through time.

- Any incremental benefits of delay of the award of the 2.6 GHz and 2010 MHz bands that might be possible through the increase of information over time are likely to be modest and, in themselves, uncertain. In contrast, the analysis described at paragraphs 6.44 to 6.48 above suggests that delaying an award would cause significant costs (in terms of forgone benefits).

- To the extent that there might be any inefficiencies in allocation of spectrum under an early award, it will always be possible for these to be addressed through trading in the secondary markets (e.g. if one party acquired more spectrum than they subsequently needed then they could sell this at a later date).

6.77 On balance, therefore, Ofcom believes that the appropriate course of action is likely to be to award the spectrum as soon as practicable, subject to potential developments in the European regulatory position, discussed below.

6.78 Ofcom will keep under review the level of interest in participation in the auction as a relevant test of the significance of uncertainties in respect of substitute spectrum.

Question 5: Do you agree that it is likely to be in the interests of citizens and consumers to proceed with the award of the 2.6 GHz and 2010 MHz bands as soon as practicable, rather than to delay the award pending reduction in uncertainty relating to other bands?

Implications of potential EU harmonisation measures for timing of awards

6.79 Another area which was identified at the time when stakeholders responded to the SFR:IP as requiring increased clarity was that of potential harmonisation at EU level. Several MNOs, IEEE 802, Kingston Communications and Pipex for example considered that it was either necessary or very important to have clarity on harmonisation initiatives in Europe before the 2.6 GHz band and the 2010 MHz band were awarded.

6.80 The relevant issue here is whether the RSC might, at some point if the future, make a Decision on the 2.6 GHz band and 2010 MHz band and whether such a Decision would be likely to be at variance with the proposals put forward in this consultation. The significance of an RSC Decision is that it would be binding on UK as explained in section 4.

6.81 As discussed at paragraphs 4.38 to 4.50, there are on-going discussions within the RSPG and the RSC and the European Commission has issued a mandate to CEPT on WAPECS which covers the 2.6 GHz band and the 2010 MHz band. In preparing its proposals for the award of the three bands, Ofcom has taken full account of the nature of those discussions in European regulatory groups, in particular the RSPG's opinion on WAPECS[84] and the scope of the EC's mandate to CEPT[85].

6.82 In its opinion, the RSPG identifies "ensuring an innovation-friendly and coherent regulatory environment which facilitates rapid access to spectrum for new technologies and leads to the provision of a wide variety of wireless electronic communications services and networks" as part of the overall policy framework for spectrum management in Europe. The RSPG also expresses the view that spectrum management should be made "more responsive to the rapid development of new markets and services". Ofcom considers that making the bands available as soon as practicable is consistent with this principle, in the light of the potential demand for use of the spectrum.

6.83 The scope of the on-going work in CEPT, in response to the EC's mandate, is to identify common and minimal (i.e. least restrictive) technical conditions across a range of frequency bands, which includes the 2.6 GHz band and the 2010 MHz band. Again, Ofcom considers that its approach for the available bands, as set out in section 7 (on packaging) and section 9 (on technical conditions for wireless telegraphy) is consistent with the objectives of the mandate.

6.84 More generally, in preparing its proposals, Ofcom has sought to comply with its duties under UK and EU law, including in relation to the desirability of making decisions that are technology neutral. Ofcom therefore anticipates that the risk of significant inconsistencies between its proposals and a potential European decision is likely to be low. Being a party to the relevant on-going European discussions, Ofcom will also share its analysis with its counterparts to inform discussions.

6.85 For the above reasons, Ofcom considers that there it is relatively unlikely that any future RSC Decision would be materially at odds with the approach that we are proposing on this consultation. We also note that there is no certainty that the RSC will make a Decision in relation to these bands; for example, it may not prove possible for the European member states to reach a sufficient degree of consensus on proposals for a harmonised approach to be adopted. Accordingly, we consider it appropriate to consult now on the award of the three bands, given that the benefits of releasing the spectrum are expected to be significant and to be greater the earlier the release.

6.86 However, Ofcom will keep its position under review in the light of developments within CEPT, RSC and RSPG.

Proposals on timing of awards

6.87 Ofcom proposes that the award of the three bands should take place as soon as practicable since the bands are currently unused or underused, that there is evidence

[84] Opinion published on 23 November 2005. See document RSPG05-102, available at http://europa.eu.int/information_society/policy/radio_spectrum/docs/by_topics/rspg05_102_wapecs.pdf.

[85] Mandate of 5 July 2006, available at http://europa.eu.int/information_society/policy/radio_spectrum/docs/current/mandates/ec_to_cept_wapecs_06_06.pdf.

of significant demand for use of this spectrum for a range of new applications, that these new applications are likely to result in significant welfare benefits, and that any advantages of delaying the awards to increase certainty of information on substitute spectrum are likely to be small when set alongside the forgone benefits of delay.

6.88 The earliest date that the awards could be held is likely to be towards the end of 2007. Ofcom recognises, however, that there are factors that could cause this timetable to be delayed, for example developments in the European harmonisation debate.

6.89 The above considerations on timing of awards apply most particularly to the 2.6 GHz band. They also apply in varying degrees to the 2010 MHz and 2290 MHz bands. There are some additional considerations which influence the relative timing of the award for each of the three bands. These considerations relate primarily to sequencing and are discussed in section 8.

Question 6: Do you agree Ofcom should aim to award the bands 2500-2690 MHz, 2010-2025 MHz and 2290-2302 MHz by the end of 2007, while keeping the position on the 2.6 GHz and 2010 MHz bands under review in the light of possible developments in European regulatory fora?

Flexibility in use of spectrum

6.90 Section 2 (paragraphs 2.46) and Annex 7 describe the potential uses for which there is an interest in gaining access to the bands. One important observation is that there is a wide range of potential applications and that these reflect a number of different technologies some of which have different spectrum requirements. It is Ofcom's position that it will be best to allow the market to determine which of the applications would allow maximum benefit to be derived from use of the spectrum.

6.91 These observations support Ofcom's general position in support of technology neutrality in the licence conditions discussed at paragraphs 6.95 to 6.110 below. A more specific implication is that there could be a material diminution of benefit if the auction design were to restrict unnecessarily the flexibility with which the spectrum can be allocated as between different groups of technologies. The key consideration in this context relates to the flexibility in allocation between paired and unpaired spectrum.

6.92 In the introduction to this document, at paragraph 2.46, we identified that the main potential uses of the available bands could be divided into paired use (using FDD technologies) and unpaired use (using TDD or unidirectional technologies). Ofcom considers that there is evidence of demand for the three bands and in particular the 2.6 GHz and the 2010 MHz bands from both of these categories of technology. However, as discussed further in section 7, it is not clear what the optimal amount of unpaired spectrum and what the optimal amount of paired spectrum would be. As a result, Ofcom is proposing that the relative amounts for paired and unpaired use in the 2.6 GHz band should be determined as part of the auction. This means that the outcome of the award could be in accordance with the band plan identified in ECC Decision (05)05 or it could be different, if more than 50 MHz were awarded for unpaired use.

Conditions for use of the bands – non-technical licence provisions

6.93 Ofcom has discussed its policy on a range of non-technical licence conditions in various consultation documents over the past three years, notably in the Trading

Statement and the SFR:IP Interim Statement. The RA had previously engaged on the introduction of associated reforms for some time. For example, the potential for the introduction of trading of spectrum licences and of flexibility in their use was set out in such documents as the white paper “Spectrum Management: Into the 21st Century”[86] presented to Parliament on 17 June 1996, the consultation “Managing Spectrum through the Market” of October 1998[87] and the UK Spectrum Strategy statement of 2000[88]. The Information Memorandum for the 3G auction of 2000, published in November 1999, also includes references to the scope for introduction of spectrum trading and to the consultation of October 1998[89].

6.94 In the following paragraphs, we set out in summary the reasons for proposing that the licences for the three available bands be:

a) technology and service neutral;

b) tradable;

c) of an indefinite term with an initial term (during which Ofcom’s power to revoke a licence is limited); and

d) free of other non-technical licence conditions (such as roll-out obligations).

Technology and service neutrality

6.95 As set out elsewhere (see in particular the SFR Statement, SFR:IP Interim Statement and Liberalisation Statement) and consistent with its statutory duties, Ofcom’s preferred approach is to impose the minimum necessary restrictions in existing wireless telegraphy licences, giving users more freedom to make use of the spectrum and to deploy the most appropriate services and technologies. Equally, when granting new wireless telegraphy licences Ofcom considers that it should avoid restricting the technology that may be used, or the type of service that may be offered, wherever possible.

6.96 Any restrictions on spectrum use must be justifiable and proportionate. In matters such as the selection of a technology, or service offering, the risks and potential adverse consequences of regulatory error are high. This is not least given the present rate of change in the communications sector and the imperfect nature of the information available to the regulator. Regulator-led decisions on the technology to use, or service to offer, can have large distorting effects on competition and on the efficient use of resources. There is also no need for Ofcom to specify the technology or service to be used provided the essential requirements of interference management are met.

6.97 Ofcom considers that neutrality in these respects is consistent with the Framework Directive, which requires that national regulatory authorities take the utmost account of the desirability of making regulations technologically neutral. As a consequence, Ofcom is required in section 4 of the Communications Act 2003 to meet a number of

[86] See section 8 in particular. The document is available at http://www.ofcom.org.uk/static/archive/ra/topics/spectrum-strat/document/sm_96/specintr.htm.
[87] See paragraphs 3.3 or 4.4 for example. The document is available at http://www.ofcom.org.uk/static/archive/ra/publication/ra_info/ra335/ra335.htm.
[88] See section 1.5 for example. The document is available at http://www.ofcom.org.uk/static/archive/ra/topics/spectrum-strat/future/strat00/index.htm.
[89] See section 2.2.8. The document is available at http://www.ofcom.org.uk/static/archive/spectrumauctions/Information%20Memorandum/index.htm.

duties relating to “Community requirements”. One of these is a requirement to act in a technology neutral way.

6.98 Consistent with this general approach, Ofcom intends to release unused bands to the market with only those technology and usage restrictions that are the minimum necessary for the efficient management of the radio spectrum and the avoidance of interference, and compliance with Ofcom’s statutory duties and international obligations.

6.99 Ofcom’s technical analysis indicates that it is not necessary to place any technology or usage restrictions on the 2.6 GHz, 2010 MHz and 2290 MHz bands over and above the proposed minimum technical conditions for their use discussed in section 9. Ofcom considers that this is a proportionate and objectively justifiable approach, which provides the most appropriate means of meeting Ofcom’s objectives for the award and its duties under UK and European law. It is not unduly discriminatory as it avoids differential treatment of technologies or persons and is transparent in what it seeks to achieve.

6.100 The SFR:IP Interim Statement also presents the general reasons for Ofcom’s decision to award new licences in a technology neutral fashion as part of its programme of spectrum awards (see paragraphs 3.53 to 3.67). The specific analysis as it applies to the 2.6 GHz band are detailed in the SFRIP Interim Statement[90] and in Ofcom’s response[91] to the EC’s invitation for comments of June 2005.

Spectrum trading, conditions of tenure for new licences and other non-technical licence conditions

6.101 The benefits of the introduction of spectrum trading and the associated licensing conditions on tenure (indefinite term and notice prior to revocation) are set out in the Trading Statement of 6 August 2004 (see for example paragraphs 2.10 to 2.12 and paragraphs 6.1 to 6.7). Ofcom is of the view that the 2.6 GHz, 2010 MHz and 2290 MHz bands are relevant and important candidates for the implementation of market mechanisms to incentivise efficient use of the spectrum.

6.102 The SFR:IP Interim Statement of 28 July 2005 also provided Ofcom’s position on the general framework of licence conditions that is appropriate for new licences. At paragraphs 3.28 to 3.45, Ofcom set out the rationale for proposing:

a) conditions of tenure based on an indefinite term with an initial term during which Ofcom’s power to revoke excludes spectrum management reasons; and

b) not to include roll-out obligations or so called ‘use it or lose it’ conditions.

6.103 Ofcom considers that the reasons given in the SFR:IP Interim Statement and the Trading Statement are relevant to the 2.6 GHz, 2010 MHz and 2290 MHz bands and that the new licences should be tradable, include the conditions of tenure set out above and be free of roll-out obligations.

[90] See in particular paragraphs 4.62 to 4.70 and A.12 to A.38.
[91] Submitted on 15 September 2005. See http://www.ofcom.org.uk/radiocomms/isu/sip/eu/2_6ghz.pdf or http://europa.eu.int/information_society/policy/radio_spectrum/docs/current/ong_consult/imt_2000_com/ofcom.pdf.

Trading

6.104 Ofcom believes that the introduction of spectrum trading, and the greater flexibility to change the use and configuration of licences, will be beneficial to consumers. Spectrum trading allows the right to use a particular block of spectrum to be transferred to, and used by, the user who values it most. When spectrum markets are working effectively, they provide an efficient way to ensure that more spectrum is employed in the use, and by the user, which brings the greatest benefit to the economy. Trading and allocation of radio spectrum through the market brings benefits such as:

a) the ability for efficient spectrum users to use more spectrum by acquiring it from less efficient users;

b) the possibility for more spectrum to be available more quickly for services which are popular and for which there is strong demand, with scope for cost reductions as a result;

c) an opportunity to reduce the transaction costs of acquiring spectrum; and

d) a reduction in barriers to entry with more spectrum becoming potentially available to new users without the need for regulatory intervention, thereby promoting competition and innovation.

6.105 In the case of the spectrum bands, the proposed awards are designed to ensure an efficient primary assignment and spectrum trading provides additional scope for efficiency, through the opportunity for licensees to respond to changes in conditions over time and in particular beyond the proposed initial period of the licences.

Conditions of tenure

6.106 Ofcom believes that the proposal for an indefinite term with an initial period should provide sufficient security of tenure to bidders to promote efficient use of the spectrum. This includes an initial period set on a basis that gives licensees a reasonable opportunity of recovering their investment for likely services. For the three available bands, the relevant period identified by Ofcom is of 20 years. The use of licences with an indefinite duration removes the requirement for the return of spectrum to the regulator at the end of a fixed term. This creates additional opportunities for the market to secure the efficient use of the spectrum, particularly in the presence of spectrum trading. Following the initial period, Ofcom’s view is that the indefinite term allows licensees appropriate clarity to plan further investments and operations, while being exposed to market incentives for efficient use (as the licences would be tradable and therefore potential alternative users of the spectrum may make offers corresponding to the opportunity cost for their planned use).

6.107 Ofcom is proposing two main safeguards to guard against the risks of market failure and inefficient use after the proposed initial period of 20 years. First, incentives such as Administered Incentive Pricing may be applied after the initial term of the licence has expired, in line with Ofcom’s spectrum pricing policy at the time. Second, Ofcom can also revoke a licence where it is necessary to do so for reasons of spectrum management. Ofcom has already provided some clarification of the conditions in which it could revoke a licence after the end of an initial period for spectrum management reasons, for example in the SFR:IP Interim Statement. Ofcom would only revoke or change licences for spectrum management reasons where there was a pressing need to do so, and only after careful consideration and consultation with the stakeholders affected. Examples of such reasons might be to ensure that the fulfilment of Ofcom's statutory duties, such as securing the availability throughout the UK of a wide range of electronic communications services, was not impeded by a minority user; or that spectrum did not remain unused for an excessive period. Ofcom considers that this approach, where intervention of the regulator only occurs where there is a compelling case and evidence of market failure, is appropriate to the promotion of the efficient use of the spectrum. The benefits of this approach include a reduction in the costs of making the spectrum available for new uses or new users, and a reduced need for the regulator to be involved in such changes.

Other non-technical licence conditions

6.108 Ofcom considers that roll-out obligations are unlikely to be required to meet the objective of ensuring that the spectrum is used efficiently. This is because spectrum trading and liberalisation and Administered Incentive Pricing provide or enhance the incentives to use spectrum efficiently with the relevant degree of flexibility for licensees to conduct their business. In addition, Ofcom has indicated in the Trading Statement that concerns regarding spectrum hoarding, which sometimes underlie proposals for 'use it or lose it' conditions, may be addressed ex post, for example through competition law.

6.109 Ofcom also considers that it is difficult and potentially arbitrary to set roll-out obligations when technology neutral licences and potentially varied uses are involved, as is the case with the three available bands. For example, it is not clear what roll-out obligations would be for PMSE services where use of wireless video equipment depends on the events that require coverage and associated locations can vary. Also, it may be that some uses based on particular coverage areas may in fact be more efficient and deliver greater benefits than other potential uses based on greater coverage areas. There is therefore a risk of distorting an award and potentially de facto excluding some potential users by imposing roll-out obligations.

6.110 Ofcom also does not consider that there are any inconsistencies between its statutory duties and proposed licence conditions summarised in this section.

Question 7: Do you agree with Ofcom's proposals for licence conditions (technology neutrality, tradability, conditions of tenure and absence of roll-out obligations)?

Consequences of the proposed approach and competition considerations

6.111 The SFR:IP put forward a broadly similar approach to the non-technical licence conditions and timing for the awards as has been set out under Ofcom's proposals in this section. In response to the SFR:IP some MNOs argued that the general approach set out by Ofcom for the award of the 2.6 GHz band, and potentially the 2010 MHz band, would have a number of adverse effects. In broad terms the MNO concerns can be grouped under two main areas relating to:

a) the potential for the proposed licence conditions to constitute undue discrimination or unfairness; and

b) the potential for the proposed licence conditions to adversely impact competition in relevant downstream markets.

6.112 Ofcom has carefully considered these concerns. For the reasons given below, Ofcom does not believe that these concerns provide grounds for departing from the proposals set out above.

Potential for undue discrimination and unfairness

6.113 In SFR:IP responses, 2G and 3G MNOs expressed concerns that undue discrimination could arise because the proposed licences for the available bands would allow the spectrum to be used for 3G services and the proposed licence conditions were more favourable than those in the 2G and 3G licences. They identified four main areas which they claimed constitute undue discrimination and / or unfairness.

a) Duration and notice period prior to revocation and rolling term. The licence conditions proposed in the SFR:IP and in this consultation for the three available bands are indefinite. They include an initial term (20 years for the 2.6 GHz and 2010 MHz and 2290 MHz bands), during which Ofcom's powers to revoke the licence do not include spectrum management reasons, followed by an open-ended term, during which Ofcom's powers to revoke include spectrum management reasons subject to a notice of 5 years. By contrast, 2G licences are indefinite and Ofcom's powers to revoke include spectrum management reasons subject to a notice of one year; and 3G licences have a fixed duration of 21 years and Ofcom's power to revoke does not include spectrum management reasons.

b) Roll-out obligations. The proposed licence conditions do not include roll-out obligations, while 3G licences include an obligation to provide, by 31 December 2007, a service to an area where at least 80% of the UK population live.

c) Technology neutrality. The proposed licences do not require licensees to use a particular technology while 2G and 3G licences include requirements to use GSM and UMTS respectively.

d) Capacity to trade the rights under the licence. Rights and obligations of the proposed licences would be transferable under the spectrum trading regime, while 2G and 3G licences are not currently tradable.

6.114 At a general level, Ofcom considers that past decisions on licensing conditions do not necessarily determine how future licensing decisions should be made, subject to relevant consideration of the requirements under EU and UK law (in particular section 1D(9) of the Wireless Telegraphy Act 1949 and article 7.3 of the Authorisation Directive). The 2G and 3G licences were awarded at times when different spectrum policy conditions prevailed. For example, when 2G licences were awarded in the 1990s, the conditions of spectrum scarcity were different. Also, the application of market mechanisms, such as spectrum trading and spectrum auctions, and the introduction of a technology neutral approach to spectrum awards were only being considered as policy options whereas they have since been adopted as the basis of spectrum policy following consultation.

6.115 In itself, the existence of conditions in current licences that are different from those proposed for new licences is not a justification for preventing the introduction of changes when their overall benefits have been identified and when changes to the legal framework have been made to make their implementation possible. In this context, Ofcom notes that the 3G licences have different conditions to those of the 2G licences, yet it is not aware of any claims of discrimination on that basis, nor does it believe that those differences give rise to discrimination for similar reasons to those expressed in relation to the proposed licences.

6.116 Ofcom has considered carefully whether the proposed licence terms could discriminate unduly against any person, including existing licensees in other spectrum such as the MNOs. Undue discrimination can only arise where different treatment is given to persons in similar circumstances, or where the same treatment is given to persons in different circumstances, and there is a lack of objective justification for the treatment given.

6.117 Ofcom has identified a number of differences between the proposed licences for use of the 2.6 GHz, 2010 MHz and 2290 MHz bands on the one hand and existing 2G, 3G and other licences on the other. The main differences are as follows.

a) The prevailing spectrum management policy at the time of award has changed in recognition of the benefits of market mechanisms and flexibility. As discussed above at paragraphs 6.114 and 6.115, spectrum policy conditions at the time of award were such that both 2G and 3G licences specify the technology to be used and are not tradable. 3G licences also include roll-out obligations.

b) The manner of award differs. The 2G licences were awarded by comparative selection, with the regulator (at the time, the Secretary of State) deciding who licence holders should be, not by auction.

c) International obligations are different, particularly in relation to technology neutrality relating to the relevant spectrum. The GSM Directive applies to part of the 900 MHz spectrum and its existence prevents the application of a technology neutral approach to that spectrum. At the time of 3G licence award the UMTS Decision applied, requiring a technology specific award for some of the spectrum that was awarded. In contrast, there are presently no binding international obligations on the 2.6 GHz and 2010 MHz bands.

d) Moreover, the EU legal context has changed. The Framework Directive that came into force in April 2002 permitted trading whereas, at the time of the 3G auction in 2000 it was understood in the UK that trading was not permitted under the previous Licensing Directive[92].

e) It is also possible that the services offered using the available bands could compete in different downstream markets to those served using 2G spectrum (at 900 MHz and 1800 MHz) and using 3G spectrum (at 2.1 GHz).

6.118 These differences in circumstances at time of award are such that Ofcom does not consider that the proposals involve undue discrimination. In addition, we note that the MNOs will be able to participate in any new awards for these bands on the same terms as potential new entrants. Hence, there would be no source of discrimination against them in the proposed awards themselves.

6.119 In addition Ofcom has considered four specific areas of concerns raised in relation to undue discrimination or unfairness:

- the licence term and roll-out obligations;
- the cost of rights to use the spectrum;
- the claimed lack of demand for the spectrum; and
- technology neutrality for the available bands.

[92] See in particular paragraph 2.2.8 in the Information Memorandum for the 3G auction of 2000.

Licence term and rollout obligations

6.120 Ofcom considers that the tenure conditions and roll-out obligations for the 3G licences were clearly set out at the time of the auction. In the Information Memorandum for the 2000 auction, it was made clear ahead of the award, and after consultation with stakeholders, that roll-out obligations would be included in the licences on offer. In section 2.2 (in particular paragraph 2.2.4) and at appendix K[93] of the Information Memorandum, the 3G licence condition on roll-out is clearly stated. In section 2.2.3 and in the template licence at appendix K, the duration of the 3G licences, consisting in a fixed term, was also clearly stated.

6.121 It was also made clear at the time of the 2000 auction that further spectrum would be made available that could be used for similar technologies and services (and therefore that there could be future entry into the mobile communications market)[94]. It was not stated that future awards of spectrum would be subject to the same conditions, including roll-out obligations, as in the 2000 award. The means by which future awards of spectrum would be allocated were also not stated.

6.122 Participation in the 2000 auction reflected the acceptance of those conditions. The prices paid by the winning bidders in the auction, which has been judged open, fair and transparent, should also have reflected the implications of those conditions. Similarly, we would expect the prices paid in any new award to reflect the conditions attaching to the licences to be awarded. Therefore, Ofcom is of the view that the award of licences with the conditions proposed in this consultation would not be unfair to holders of existing licences.

Cost of spectrum

6.123 In their SFR:IP responses some MNOs also claimed that the manner in which Ofcom was proposing to make the 2.6 GHz band available would be unfair on grounds relating to the low expected cost of spectrum relative to the prices which they paid in the 3G auction.

6.124 It is true that the 3G auction took place at a time when it is considered that market sentiment in the telecoms sector was at a peak in spring 2000. However prices paid in an open, transparent and non-discriminatory award process will reflect the market conditions and expectations prevailing at the time of the awards. That the prevailing market conditions change over time is not a source of discrimination or unfairness.

Absence of demand

6.125 Some MNOs suggested that holding an award on the timetable suggested in the SFR:IP could be unfair as they may not have a need for the spectrum at that time. Ofcom notes that the timetable for the award is now later than proposed in the SFR:IP and that there is abundant evidence of demand for the spectrum from other potential users (see paragraphs 6.30 to 6.39). In addition, it should be noted that there is no obligation on the MNOs to participate in the award. Therefore, Ofcom does not consider that the proposed timing constitutes undue discrimination against the MNOs.

[93] Template licence, schedule 1, paragraph 4 a): "The Licensee shall install, maintain and use Radio Equipment (as specified in paragraph 9 of Schedule 1) in such a way as to enable the provision of, by no later than 31 December 2007, and to maintain thereafter, a telecommunications service by means of the Radio Equipment to an area where at least 80% of the population of the UK live".

[94] See the Information Memorandum for the 3G auction, in particular section 3.4.1 and A5.2.

Technology neutrality & legitimate expectations

6.126 Finally, H3G also argued that the award of technology neutral licences would go against the legitimate expectations created during the 3G auction of 2000. Ofcom does not accept the argument that legitimate expectations arise as a result of the 2000 auction in respect of the policy that Ofcom should adopt towards the technologies that it should permit in the award of these spectrum bands.

Consideration of competition with regard to existing operators

6.127 In their SFR:IP responses some MNOs claimed that the proposed licence conditions for the 2.6 GHz band could lead to adverse effects on competition in downstream markets. These points were made with particular reference to:

a) the potential for adverse effects on competition in the absence of roll-out obligations; and

b) the potential for the technology neutrality conditions in new licences to undermine 3G investments.

6.128 In considering these matters, Ofcom has been particularly mindful of its duty to promote competition. Its considers that the relevant question is whether the proposals as set out above, in particular the technology neutral technical conditions and the absence of roll-out obligations fail to meet that duty. As explained below Ofcom considers that its proposals do meet its duty to promote competition.

Absence of roll-out obligations

6.129 Arguments were made to Ofcom by MNOs in response to the SFRIP consultation that differences between conditions in the proposed new licences and conditions in existing 3G licences might have an adverse impact on competition.

6.130 On the contrary, as explained above (see for example paragraphs 6.40 to 6.42) Ofcom expects that an award of this spectrum would promote competition.

6.131 It is true that the proposed licences terms, described earlier in this section, are different in some respects from those of existing licences. It is also true that this award might lead indirectly to an impact on customer numbers and market positions of the existing MNOs as a result of new market entry.

6.132 However, Ofcom does not accept that it follows from this that the award will have an adverse effect on competition. In fact any impact on customers and market positions may be a result of an increase in competition which has been enabled by new market entry.

6.133 The available spectrum offers considerable potential scope for both innovation, potentially using new technology (for new entrants or existing players), and cost reductions (for existing players). In practice, given the maturity of the overall mobile services market in the UK, it also seems unlikely that a new player would emerge without either some degree of differentiation, and therefore some degree of innovation in service provision, and / or some degree of price reduction for consumers. That new competitors could affect the relative market position of certain existing players is a desirable outcome of an open, fair and transparent award of new spectrum licences.

6.134 It appears to Ofcom that some arguments raised so far against the general approach proposed for the three available bands in the SFR:IP may be driven by a desire to avoid new competition from new entrants. Given that the availability of spectrum might currently create a barrier to entry Ofcom currently considers that it would be more appropriate, and in line with its duty to promote competition, to remove rather than retain that barrier where Ofcom is able to remove it.

6.135 Ofcom also notes the following points concerning the position of existing 3G licensees.

a) Ofcom is not proposing to prevent them from participating in the proposed awards. Therefore it is not clear why such an award would adversely impact upon the market position of any of the MNOs (regardless of any positive or adverse impact on competition).

b) The 3G MNOs also have well established commercial identities and customer bases. A new entrant would have to go through a phase of brand development to be in a position to attract customers and would initially incur higher costs as a result. Moreover, by the time competitors were able to enter the market, the 3G MNOs will have had considerable opportunity to reap the benefits of early mover advantages.

c) The proposals as set out above are for technology neutral awards. There is therefore some uncertainty regarding what downstream services will be offered and in which relevant markets those services will reside. They could be in different markets to those relevant to 3G services.

d) Experience also suggests that there are advantages to providing mobile telephony and data services to a large majority of the UK. For example, the development of 2G networks world-wide has shown that extensive network coverage has been a pre-requisite for success in mobile markets. In the UK, Ofcom understands that 2G operators offer their services to an area where up to or more than 99% of the population live, while their current authorisations do not place coverage requirements on them. This suggests that providers of mobile telephony and data services, using UMTS or other technologies, would likely seek to provide their services to significant areas of the UK and achieve significant population coverage.

e) Existing 3G licensees have a wide scope for responding to new competition in their pricing strategy (subject to competition law). They are able, for example, to target corporate or high volume customers in urban areas through their tariff policies.

6.136 In conclusion, Ofcom does not consider that the proposed licences, which do not include roll-out obligations, would be likely to have adverse effects on competition. On the contrary, Ofcom believes that the proposed awards are pro-competitive and likely to generate significant benefits for consumers.

Undermining 3G investment

6.137 Some MNOs, H3G and T-Mobile in particular, argued that allowing use of the 2.6 GHz band for technologies other than UMTS would undermine their 3G investments and create adverse conditions for further 3G investment, in the process denying them a chance to achieve a reasonable return.

6.138 It is certainly true that if there were to be new entry into markets that overlap with 3G services as a result of new spectrum awards then this could be expected to reduce the profits that the MNOs would otherwise expect to make in the absence of competition from new entrants. This is a natural consequence of competition in downstream markets which it is Ofcom's duty to promote.

6.139 Moreover, this would only be a source of concern requiring Ofcom to consider a different course of action if the new spectrum awards were to create a distortion in competition. As explained above, we do consider that the awards would promote competition. It is also not Ofcom's role to guess what technology might be the most appropriate for use of the available bands or seek to constrain the market accordingly.

6.140 Ofcom also notes that MNOs and operators wishing to use 3G technology will have the opportunity to compete in the award to acquire spectrum in support their existing businesses and to help provide new services in future.

Restrictions on the quantity of spectrum which may be acquired in the auction

6.141 The award of new licences for use of spectrum that is currently unused or underused will provide opportunities for entry in existing markets and for the emergence of new services. Therefore, the proposed awards are likely to be pro-competitive in terms of their effect on downstream markets. Moreover, in its statement on ensuring competition following the introduction of spectrum trading[95], Ofcom set out its view that the framework of ex post regulation of the Competition Act should 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, and that Ofcom has relevant powers under the Competition Act in conjunction with powers held by Ofcom under the 2003 Act, Wireless Telegraphy Acts and the Enterprise Act.

6.142 Nevertheless, Ofcom has considered below whether, in light of its duties to promote competition and to promote innovation, there might be a case to place any restrictions on:

a) the ability of specific parties to participate in the awards; and

b) the amount of spectrum which might be awarded for a particular use or that is acquired in the auction by an individual bidder.

6.143 Ofcom may also keep under review the possibility of including specific provisions within licences to support the promotion of fair and effective competition, and to guard against behaviour such as anti-competitive hoarding. Ofcom would welcome views on this point.

Restrictions on specific bidders

6.144 In its response to the SFR:IP, one MNO argued that Ofcom should carefully consider the position of BT, questioning whether it should be allowed to participate in certain awards at all and suggesting that an alternative course of action would be to specify ex ante regulatory conditions for the case where BT gains access to spectrum relevant to certain wireless broadband services. The concerns were based on BT's alleged motives to close-off infrastructure-based competition to their fixed broadband

[95] See in particular paragraphs 4.1 to 4.6. The statement is available at http://www.ofcom.org.uk/consult/condocs/sec/statement/.

offerings in order to maintain or increase its dominance in some wholesale markets for fixed telecommunications.

6.145 Ofcom's research suggests that if the available spectrum is used to provide broadband services, then these services are likely to compete mainly with mobile data communications services rather than with fixed broadband services, at least in the short term. Since these two markets are separate, Ofcom believes that BT would have little incentive or purpose in trying either to close off competition in mobile data communications in order to maintain dominance in wholesale markets for fixed telecommunications; or to leverage its dominance in markets for fixed telecommunications into the provision of mobile broadband services. Moreover, it seems unlikely that BT could gain a position of dominance as a result of the proposed awards either in the provision of mobile services (and access and call origination on public mobile telephone networks in the UK is considered to be competitive) or in the provision of new mobile or other services.

6.146 The question could, in principle, become more relevant if there is significant convergence between mobile broadband and fixed broadband services over time. However, those services are currently provided by a number of operators, a number which might increase as a result of the proposed awards and potentially other spectrum awards. Moreover, through its undertakings under the Enterprise Act 2002 and ex ante conditions imposed on it as a provider with SMP[96], BT is under specific obligations to allow use of its infrastructure by other providers at a wholesale level for the provision of fixed voice and broadband data services to address dominance. Those provisions, in addition to infrastructure competition between BT's network and other fixed networks (including cable), increase the competitive pressures on BT at both a wholesale and a retail level. Ofcom does not believe that there is any evidence to suggest that, if BT gained access to spectrum for the provision of wireless services in the 2.6 GHz or 2010 MHz bands, it would necessarily require further regulation as a direct result of the spectrum holding. However, if Ofcom becomes aware of the need for modifications in remedies then we will address them. As noted above, Ofcom also has ex post competition powers which can be used to address anti-competitive behaviours in certain circumstances.

6.147 Finally, we note that if BT, or any other party, were to attempt to acquire spectrum under these awards with a view to foreclosing entry into the broadband market, whether the current mobile broadband market or a future converged broadband market, a foreclosure strategy of this sort would be likely to be prohibitively expensive, given the amount of spectrum to be made available and the prospective interest in the band.

6.148 For the reasons above, Ofcom does not consider it necessary to place restrictions on any individual company, and in particular on BT, in respect of their participation in the awards.

[96] See the statement on the Strategic Review of Telecommunications, published on 22 September 2005 (http://www.ofcom.org.uk/consult/condocs/statement_tsr/statement.pdf), and associated documents on local loop unbundling and wholesale line rental, such as it statements of 30 November 2005 (http://www.ofcom.org.uk/consult/condocs/llu/statement/), 15 December 2005 (http://www.ofcom.org.uk/consult/condocs/line_rental/wlrffp_statement/) and 24 January 2006 (http://www.ofcom.org.uk/consult/condocs/wlrcharge/statement/).

Restrictions on the amount of spectrum awarded to individual bidders

6.149 We have considered whether there is a case for placing restrictions on the award outcome for the purpose of ensuring competition in the provision of innovative services. There are a number of reasons why trying to design an award outcome with stringent measures would be undesirable. The main proxy for identifying innovation before an award would likely be with reference to technologies. However, if Ofcom was to reserve some spectrum for particular technologies on these grounds it would be difficult to identify which new technologies should be given access to such reserved spectrum. In fact, evolutions of existing technologies might allow comparable innovation. It may also be the case that new technologies turn out not to support the most efficient use of spectrum.

6.150 Another consideration might be whether Ofcom should apply specific measures as part of the award conditions in order to ensure a minimum number of players in downstream markets. Ofcom is not aware of any compelling evidence that would support such an approach. Determining the appropriate minimum number of players would be extremely challenging. It may also restrict optimal use of the spectrum by limiting the amount of spectrum for certain efficient uses. Ofcom expects the award of the 2.6 GHz and 2010 MHz bands in particular to be competitive, with significant demand from a number of parties. As part of the proposals for an open, fair and transparent award process designed to promote optimal use of the spectrum, Ofcom considers it likely that the market could efficiently determine the winning bidders and their respective amounts of spectrum. Devolving this decision to the market is conducive to the efficiency of the outcome as it is likely to hold more and better information than the regulator on associated technical and commercial issues. As discussed in more detail in section 8 and Annex 8, Ofcom is proposing an auction that aims to allow all demands for the proposed licences, be they for small or large amounts of spectrum, to compete fairly. Moreover, because of the large amount of available spectrum, it also seems likely that a number of parties would win access to spectrum in the proposed award for the 2.6 GHz and 2010 MHz bands.

6.151 Another possibility for achieving a broadly similar purpose would be to impose a limit on the amount of spectrum any one bidder could win, i.e. a spectrum cap, and set this limit at a level likely to maximise the number of efficient licensees.

6.152 However, the uncertainties concerning an optimal assignment include the amount of spectrum that each potential FDD or TDD operator should receive as a result of an award. There are several types of services that could be delivered using the available bands and there are likely to be a number of different strategies for providing these services. Ofcom is not in a position to judge accurately which of those are most likely to ensure optimal use of the spectrum. For example, it is not clear whether optimal use would be best served by a large number of players using relatively small spectrum blocks or by a smaller number of players using larger spectrum blocks. The Consultants' market research suggests that a number of potential users of the 2.6 GHz and 2010 MHz band could require around 30 MHz of spectrum fully usable for high power operations. However, this information seems too limited to form the basis for a spectrum cap. It could be that some efficient uses not specifically identified in the market research could require more, say for example, 60 MHz of unrestricted spectrum. The present consultation includes technical information that was not previously available from Ofcom that could result in reassessments by potential bidders' of their spectrum requirements.

6.153 A relatively low spectrum cap, close to the maximum amount that most bidders may need (e.g. in the range of 30 MHz to 60 MHz), would present a high risk of excluding potentially efficient uses that could in fact deliver larger benefits to consumers.

6.154 However, Ofcom recognises that there is a small chance that a large amount of the available spectrum could be won by one party. In such an outcome, the scope for competition in the provision of innovative services might not be as developed as it could otherwise be (to the extent that their provision would be conditional on use of the available bands). As discussed above, in light of the identified demand, there is a low probability of this occurring. However, the adverse consequences on competition and ultimately on consumers could be significant. Therefore, there may be a case for Ofcom to impose a spectrum cap for each participant in the award, but setting that cap sufficiently high so that it did not interfere with the ability of bidders to acquire spectrum that would support the efficient provision of services: a “safeguard” spectrum cap. The costs associated with this safeguard cap would therefore be limited, which makes it more likely that the costs would be lower than the potential benefits of having a cap.

6.155 On the basis of the available information, if there were to be a safeguard cap, then this cap could be set at 90 MHz, a level which is comfortably higher[97] than the largest individual requirement of which we are aware. This would allow one bidder to acquire up to 2 x 45 MHz of paired spectrum, up to 90 MHz of unpaired spectrum or an equivalent combination. The precise way that a cap of this sort would apply across the different bands for award depends on the way that the bands are grouped for auction. Although the level of a safeguard cap could be sensibly and safely set at a number of different values, the choice of 90 MHz would ensure that a minimum of two bidders could win access to spectrum in the 2.6 GHz band, and probably three, depending on the market’s view of proposed restrictions on certain blocks for the purpose of avoiding harmful interference. It would also be unlikely to exclude likely legitimate plans for use of the bands.

Question 8: Do you have views on whether or not there should be a “safeguard” cap on the amount of spectrum that any one bidder could win in an award for the 2.6 GHz bands and, if so, do you have a view on whether 90 MHz would be an appropriate size for a safeguard cap?

Summary of Ofcom’s proposals for the award of the spectrum bands

6.156 In summary, the proposals for the general approach on which Ofcom is consulting are as follows.

a) To authorise use of the spectrum bands by means of licensing, using auction mechanisms.

b) To hold the auctions as soon as practicable. The awards of the three bands could take place in the latter part of 2007, although this timing is subject to a number of considerations including European regulatory developments.

c) To award licences which are-

- technology and application neutral;
- tradable;

[97] Set at 50% above 60 MHz

  - of an indefinite term with an initial term after which Ofcom may revoke licences on spectrum management grounds (subject to a specific notice period); and

  - without other non-technical licence requirements on how licensees should use the spectrum.

d) To allow participants in the award to aggregate spectrum blocks as necessary, *either* without limiting by rule how much spectrum any one bidder could win *or* subject to a maximum amount of spectrum of around 90 MHz that any one bidder could win in an award that includes the 2.6 GHz band.

Section 7

Spectrum packaging

7.1 In this section Ofcom describes its proposals and rationale for the packaging of the rights and obligations that would be granted under the wireless telegraphy licences made available through the awards we are proposing.

7.2 Ofcom's wider principles for spectrum management, as discussed in sections 2 and 6, suggest that, in general, decisions on how spectrum is used should be left to the market rather than determined by the regulator. However, spectrum needs to be 'packaged' in some way in order for Ofcom to make it available to the market. It is important that this is done in a way that facilitates efficient use.

7.3 In order to achieve this, Ofcom needs to have an understanding of the most likely uses of the spectrum, and to consider how this can be reflected in the packages offered to the market.

7.4 The proposals below have been prepared in light of the objectives identified for the awards and in light of Ofcom's statutory duties. They take into account all the relevant evidence that is available to Ofcom, including the outcome of the consultation on the SFR:IP as well as the findings of the Consultants.

7.5 This section begins with a summary of the SFR:IP proposals that related to the packaging of these bands. It then considers whether the spectrum should be awarded on a regional basis or for the whole of the UK. For each of the 2.6 GHz, 2010 MHz and 2290 MHz bands in turn, it then covers the following issues:

- the spectrum requirements of candidate uses and technologies and, hence, the choice of lot size;
- in the case of the 2.6 GHz band, how the packaging arrangements should best manage variations from the CEPT band plan in terms of the split between paired and unpaired spectrum and in terms of the 120 MHz duplex spacing;
- the impacts of adjacencies on the design of lots at or near boundaries;
- the implications for packaging of adjacencies between different uses within the band itself; and
- the resulting proposals for packaging the band for award.

Overview of the proposals outlined in the SFR:IP

7.6 Ofcom consulted on outline proposals for the award of the three bands in the SFIR:IP and the proposals within this consultation take account of the responses received.

2500-2690 MHz

7.7 Ofcom proposed to award the band in 2006/07 on a technology neutral basis, subject to any constraints resulting from a binding EU decision. Ofcom also specifically invited views on preliminary considerations relating to the packaging of the band for an award. This included a discussion of whether both FDD and TDD blocks should be included in the same packages. Ofcom had also considered the option of defining specific packages with restrictions on the number of packages any one bidder could get, or offering unitary packages which bidders could combine.

2010-2025 MHz

7.8 Ofcom proposed to award one or more technology neutral licences for the UK in 2005/06 subject to constraints deriving from EU law. Ofcom also invited comments on the option of linking the award of the 2010 MHz band with that of the 2290 MHz band. The benefit of such a linkage envisaged at the time was that potential users might want to pair the two bands.

2290-2302 MHz

7.9 Ofcom proposed to award one or more technology neutral licences for the UK and, as above, suggested that the pairing of the band with 2010-2025 MHz could be an option.

UK or regional licences

7.10 Ofcom’s proposal in the SFR:IP was to award the three bands on a UK-wide basis. Two respondents (BAA and the Telecommunication Association of the UK Water Industry) suggested that it should be possible to obtain regional licences as a result of the awards; most respondents did not object or comment on the proposal for national licences. Further evidence on whether there is a market preference for UK-wide licences or otherwise was sought by the Consultants during their market assessment. As part of the detailed interview programme, the clear preference from participants was for UK-wide spectrum.

7.11 In general it is more spectrally efficient to allocate spectrum across the UK as a whole rather than at a more granular level. This is due to the need to leave either spectrum unused and/or leave areas without coverage between different geographical services in order to avoid interference between providers in adjacent regions. In contrast, an operator offering across the UK the same services as regional providers would not need to leave any gaps in its spectrum use or coverage and would therefore be able to use the available spectrum more efficiently. Northern Ireland is different in this respect from other parts of the UK in that it shares a land border with the Republic of Ireland but not with the rest of the UK. Regardless of whether the UK awards national or regional licences, some degree of coordination is likely to be required with neighbouring countries through bilateral co-ordination between respective spectrum administrations of different jurisdictions and operators in neighbouring countries; this is considered in sections 5 and 9.

7.12 In addition, it would be particularly difficult for the regulator to determine for the award the exact geographical areas for non-UK licences and it is not clear how potentially conflicting views from likely candidates for use would be resolved ahead of an award. Geographical segmentation may also increase the likelihood of unassigned licences which would not promote efficient use of the spectrum.

7.13 Spectrum trading offers scope for regional use to emerge post award from a national licence. This type of transaction is likely to be more feasible than the converse situation in which trading is used to rebuild a national use once regional licences have been awarded to different parties. This is because, in the latter scenario, there is likely to be greater scope for complexity, cost and inefficiencies since several licensees are likely to be required to trade with an operator seeking aggregation to a national level as opposed to a single operator selling parts of a UK licence which would potentially only need to deal with one counterparty.

7.14 Taking all these considerations into account, Ofcom considers that the spectrum should be offered on a UK-wide basis for each of the three bands.

The 2.6 GHz band

Spectrum requirements of candidate uses and technologies

7.15 In order to decide what packaging arrangements are most appropriate to meet the objectives for the awards, Ofcom needs to take into account the range of technologies that may be deployed as well as their frequency requirements.

7.16 In response to the SFR:IP, those stakeholders who considered packaging as an issue generally considered that unitary lots of 5 MHz would be most appropriate. BT argued that there should be FDD lots of 2 x 5 MHz and TDD lots of 5 MHz for the award of the 2.6 GHz band, with scope for the aggregation of several lots. Vodafone specifically referenced 5 MHz lots for the 2.6 GHz band. The WiMAX Forum argued that packaging for the 2.6 GHz band should be based on 5 MHz channel raster. Only Nomad suggested a potentially different option, with lots of 6 to 10 MHz for the 2.6 GHz band.

7.17 As discussed at paragraph 2.47, paired lots of 2 x 5 MHz (with a duplex spacing of 120 MHz) and unpaired lots of 5 MHz are suitable to allow the most likely technologies to use the 2.6 GHz bands.

7.18 Paired lots would allow FDD use in the 2.6 GHz band. Other uses for paired lots, such as pairing some of them with external bands, may be possible although they seem less likely.

7.19 Unpaired lots would facilitate:

- TDD use in the 2.6 GHz band;
- pairing the 2.6 GHz band with external bands (e.g. the 2010 MHz band); and
- unidirectional / broadcast use[98] in the 2.6 GHz band.

7.20 Most potential technologies use either paired channels of 5 MHz (2 x 5 MHz) or unpaired channels of 5 MHz or use channels of a size that is an integer multiple of those sizes (e.g. 2 x 10 MHz or 10 MHz), or their required channel size is such that an integer number will fit efficiently in a 5 MHz lot. This is also illustrated by the information in the list of potential technologies included at Annex 7.

7.21 The benefits of not specifying the exact size of packages and of allowing aggregation of lots based on units of 5 MHz were also highlighted in a SFR:IP response and in the Consultants' market research. Siemens considered that aggregations of lots of up to 20 MHz should be allowed for FDD use. The Consultants' analysis suggested that FDD operators were likely to have demand for lots of 2 x 5 MHz and up to 2 x 20

[98] Unidirectional use refers to applications that do not have a return channel from users' equipment to network base stations, transmissions being only from network base stations to users' equipment.

MHz while TDD operators were likely to have demand for lots of 10 MHz or 15 MHz and up to 30 MHz or more (not including guard bands).

7.22 Ofcom therefore proposes to package the spectrum as lots of 2 x 5 MHz for paired use and 5 MHz lots for unpaired spectrum. Ofcom also proposes to allow aggregation of lots by bidders subject, potentially, to a safeguard cap as discussed at paragraphs 6.149 to 6.155.

Question 9: Do you agree with Ofcom's proposal to package spectrum as lots of 2 x 5 MHz for paired use and 5 MHz lots for unpaired spectrum and to allow the aggregation of lots by bidders?

Variation from the CEPT band plan of ECC Decision (05)05 for the 2.6 GHz band

7.23 The band plan adopted by CEPT for the 2.6 GHz band, through ECC Decision (05)05, is described at paragraph 4.25. It specifies particular paired frequencies for IMT-2000/UMTS FDD use (2x70 MHz at 2500-2570 MHz and 2620-2690 MHz) and specific unpaired frequencies for IMT-2000/UMTS TDD use (50 MHz at 2520-2620 MHz). It also says that any guard bands necessary between the paired and unpaired portions of the band should be taken from the unpaired portion. For reasoned set out later in this section, the need for a 5 MHz buffer between FDD and TDD use would reduce the fully useable portion of the centre gap from 50 MHz to 40 MHz.

7.24 The CEPT arrangement has been designed to maximise the amount of spectrum for FDD within the 190 MHz available, based on the assumption of a fixed duplex spacing of 120 MHz between an FDD uplink block and its paired FDD downlink block. ECC Decision (05)05 is not binding on the UK. However, the band plan it includes has formed the basis for international discussions on use of the 2.6 GHz band and provides an important reference point for Ofcom's analysis of the packaging options.

7.25 Ofcom believes that imposing the specific CEPT band plan as part of an award of the 2.6 GHz band may to lead to sub-optimal use of the spectrum, as it would preclude outcomes which could result in greater benefits as explained in paragraphs 6.90 to 6.92 and discussed further below.

7.26 The SFR:IP responses showed a high level of interest in TDD use of the 2.6 GHz band and some respondents suggested the need for minimum amounts of bandwidth that, added together, could well be larger than the 50 MHz identified for unpaired use in ECC Decision (05)05 (allowing for the assumption in the CEPT plan that guard bands would be taken out of this centre block of unpaired spectrum).

7.27 The information assembled by the Consultants through their interviews and analysis supports the suggestion made in SFR:IP responses that the amount of unpaired spectrum available under the provisions of the CEPT band plan of ECC Decision (05)05 may not be sufficient to meet the requirements of operators for developing TDD services. For example, if an individual operator required more than 40 MHz of fully useable spectrum, then it would either be excluded entirely under the CEPT plan, or it would not be able to develop its plan fully (even though it may have been able to make more valuable use of the blocks adjacent to the centre band than FDD operators could). The Consultants also received feedback that WiMAX applications, one of the main candidates for use of the unpaired spectrum, might require a minimum of 30 MHz. On this basis, a restriction on the centre part of 50 MHz would prevent all but one operator from acquiring the unpaired spectrum they would need.

7.28 An alternative to the CEPT band plan might be to specify a different allocation as between paired and unpaired use, perhaps with an allocation of more than 50 MHz for unpaired spectrum that is suitable for TDD use. But it would be very difficult to make an objective decision as to what an appropriate split might be. There would be a risk of regulatory error in any decision on that point. The Consultants considered a number of scenarios for the development of different services using the 2.6 GHz band, analysing for each scenario the relative demand for FDD and TDD spectrum in an auction. They concluded that the relative demand for TDD or FDD use was particularly uncertain: in some scenarios TDD applications would be likely to require most of the 190 MHz available in the 2.6 GHz band while in other scenarios FDD applications would be likely to require most of the band. If Ofcom were to pre-determine an allocation that was different to the underlying market demand then this would lead to sub-optimal use of the spectrum and a material loss of benefit from bringing the spectrum into use.

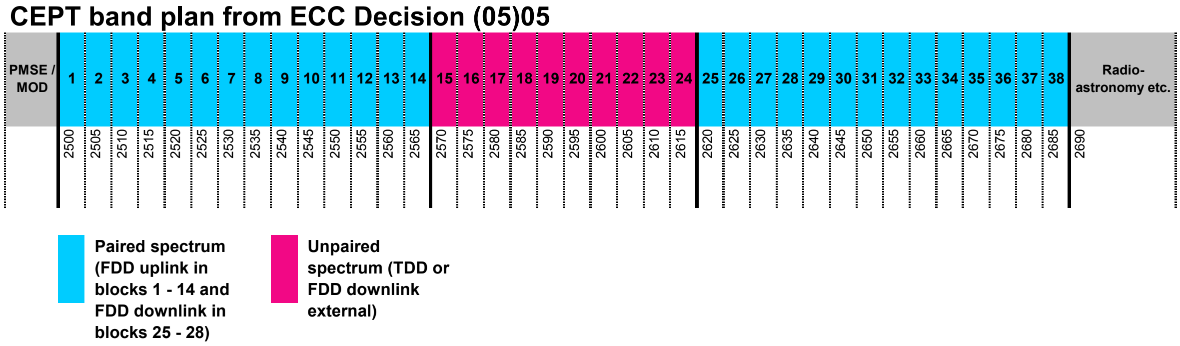
7.29 In the light of the market analysis prepared by the Consultants and SFR:IP responses, Ofcom believes that it is undesirable for the regulator to determine how much spectrum would be available for paired and unpaired use. It is also unnecessary, as it is possible for the market to determine that split. This can be done by allowing the auction mechanism to establish the relative amounts of spectrum for paired and unpaired use on the basis of participants' demand.

7.30 Under such an approach an outcome consistent with the CEPT band plan would be possible. But it would not be imposed; in particular, it would also be possible for the amount of spectrum used by TDD applications to exceed the 50 MHz centre part.

Flexibility between paired and unpaired spectrum for the 2.6 GHz band

7.31 Ofcom is proposing to allow the auction to determine the precise split between paired and unpaired spectrum in the 2.6 GHz band. However, in other respects, Ofcom considers that it is desirable to maintain as much compatibility with the CEPT band plan where this is possible. In particular, Ofcom considers it is important to maintain a channel plan based on minimum block sizes of 5 MHz, to maintain the approach that for paired spectrum the uplink should be in the lower portion of the band and the downlink in the upper portion, and (subject to the discussion in paragraphs 7.33 to 7.39 below) to maintain a duplex spacing of 120 MHz. This approach is desirable as it will help to avoid a situation where terminals built to work with the CEPT plan elsewhere in Europe could not be used in the UK. The issue around flexibility then becomes one of how best to accommodate a split between paired and unpaired spectrum which is different from the split in the CEPT band plan in ECC Decision (05)05, illustrated in Figure 7 below.

Figure 7: relative amounts of paired and unpaired spectrum in the 2.6 GHz band in ECC Decision (05)05



7.32 A market solution to identifying an appropriate split between the amount of paired and unpaired spectrum could lead to two different outcomes (if it does not lead to the same outcome as the CEPT plan). The first would result from demand for more paired spectrum than the 2x70 MHz in the CEPT band plan. According to our market analysis this is actually the less likely outcome. However if more paired spectrum were required then, as considered in ECC Decision(05)05, some of the 50 MHz in the centre unpaired portion of the band could be externally paired with the 2010 MHz band allowing the total amount of paired spectrum to increase. It is also worth noting that the CEPT plan also allows for some of the centre unpaired portion of the band to be externally paired with the band 1900 - 1920 MHz which is currently assigned to four of the five 3G operators in the UK. Note that if the duplex spacing of 120 MHz between two paired blocks is to be maintained then it would not be possible to increase the amount of paired spectrum within the 2.6 GHz band itself as the CEPT band plan has already been devised so as to maximise the amount of paired FDD spectrum with this duplex spacing.

7.33 The second outcome would result from demand for unpaired spectrum exceeding 50 MHz. In this scenario there are two main options for expanding the unpaired proportion within the 2.6 GHz band:

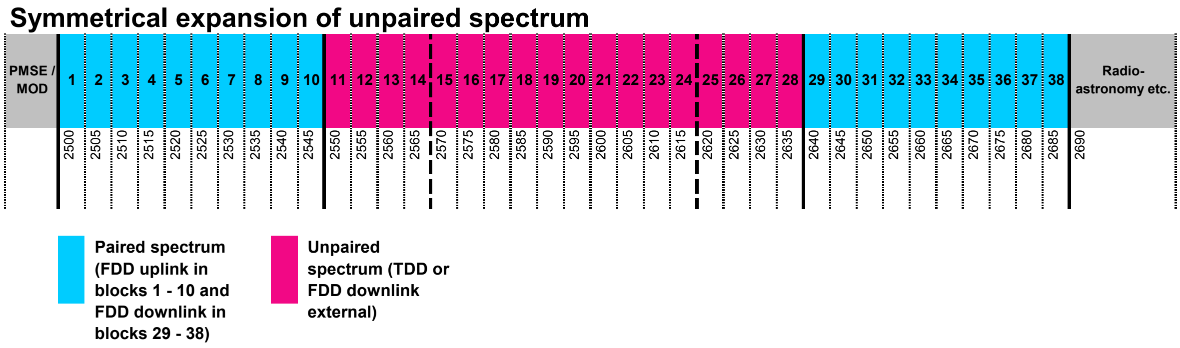
a) allow the centre portion of unpaired spectrum to expand symmetrically around the centre of the band and abandon the 120 MHz duplex spacing constraint; and

b) maintain the 120 MHz duplex spacing but introduce a second block of unpaired spectrum at one or other end of the band.

7.34 One of the factors to consider when deciding how best to accommodate an increased demand for unpaired spectrum is that it is desirable to minimise the number of boundaries between paired and unpaired spectrum. This is because adjacent blocks where one is used for unpaired / TDD and one is used for paired / FDD cannot be deployed at normal powers without a high risk of interference between the two adjacent users. As explained in paragraphs 7.46 to 7.54 below there will be a need for significant power restrictions on one 5 MHz block between adjacent paired and unpaired use (effectively reducing it to pico-cellular powers) and the second adjacent 5 MHz blocks (either side of the restricted block) would require a tightened out-of-band mask.

7.35 The first option would be to abandon the 120 MHz duplex spacing constraint and allow the centre portion of unpaired spectrum to expand symmetrically around the centre of the band. In the example illustrated below, the unpaired portion of the band has expanded by 40 MHz (20 MHz at each side of the centre unpaired portion of 50 MHz). This results in the paired spectrum changing to a 140 MHz duplex spacing with channel 1 being paired with channel 29 and so on.

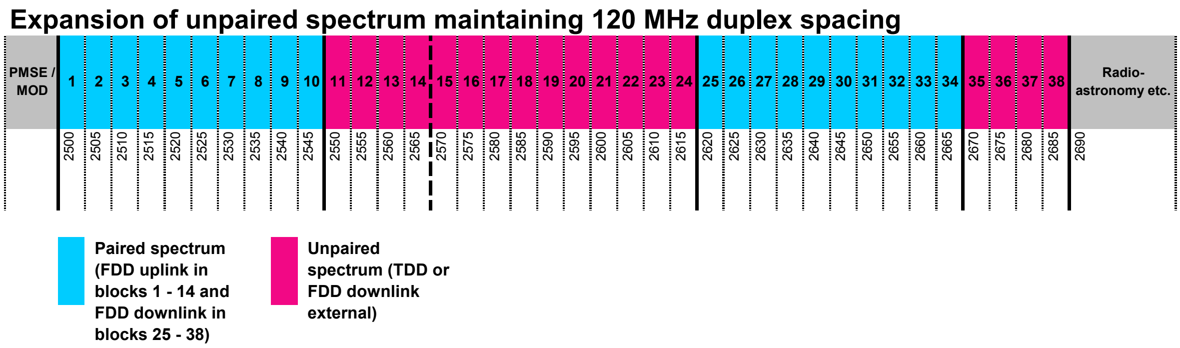
Figure 8: Illustration of the symmetrical expansion of the amount of unpaired spectrum at 2.6 GHz relative to the CEPT band plan (duplex spacing different from 120 MHz)



7.36 The advantage of this option is that no additional restricted blocks of spectrum are necessary, as the number of boundaries between paired and unpaired spectrum would be unchanged. A significant disadvantage is that the current 3GPP specifications for UMTS FDD would need to be modified as they currently do not cater for alternative duplex spacings to 120 MHz in the 2.6 GHz band and UMTS FDD is one of the main potential technologies for paired use. The specifications could be modified to add additional duplex arrangements but, unless the duplex spacing that results from the award in the UK is mirrored elsewhere in Europe or internationally, a UK specific arrangement may be inevitable. Another disadvantage is that terminals designed for the CEPT band plan would be less likely to be usable in the UK.

7.37 The second option would be to maintain the 120 MHz duplex spacing but to introduce a second block of unpaired spectrum at one or other end of the band. For reasons of interference management with adjacent bands (see paragraphs 7.43-7.45 below) it would be preferable to introduce the extra unpaired blocks at the top end of the band, rather than at the bottom of the band, as illustrated below.

Figure 9: Illustration of the expansion of the amount of unpaired spectrum at the top end of the 2.6 GHz band relative to the CEPT band plan (duplex spacing of 120 MHz)



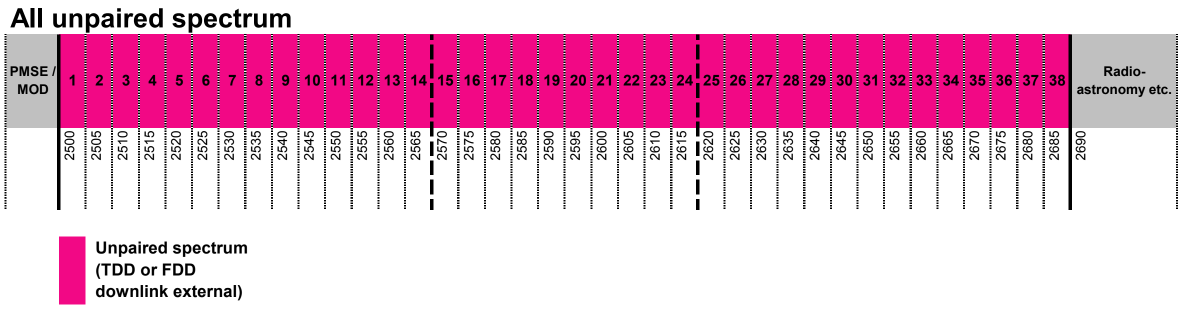
7.38 The advantage of the above example is that the 120 MHz duplex spacing is kept, thus maintaining compatibility with the current 3GPP specifications for UMTS FDD, and increasing the likelihood that FDD terminals designed according to the CEPT band plan would be useable in the UK. The disadvantage is that an extra paired/unpaired boundary would be created (at 2670 MHz in the example of Figure 9, the adjacency between blocks 34 and 35) thus increasing the amount of spectrum whose use would need to be restricted.

7.39 Ofcom's favoured approach to varying the ratio of paired to unpaired spectrum is the second option, as we consider that the advantage of maintaining the 120 MHz duplex spacing outweighs the disadvantage of introducing one more boundary between paired and unpaired use. This is the approach adopted for the packaging proposals described below.

7.40 For either of the above options for expanding the amount of unpaired spectrum, there would be an increased risk of mobile to mobile blocking between FDD and TDD mobiles. However, based on analysis conducted by Ofcom and the Consultants, this increase is considered acceptable (see the separate technical reports published alongside this consultation for details).

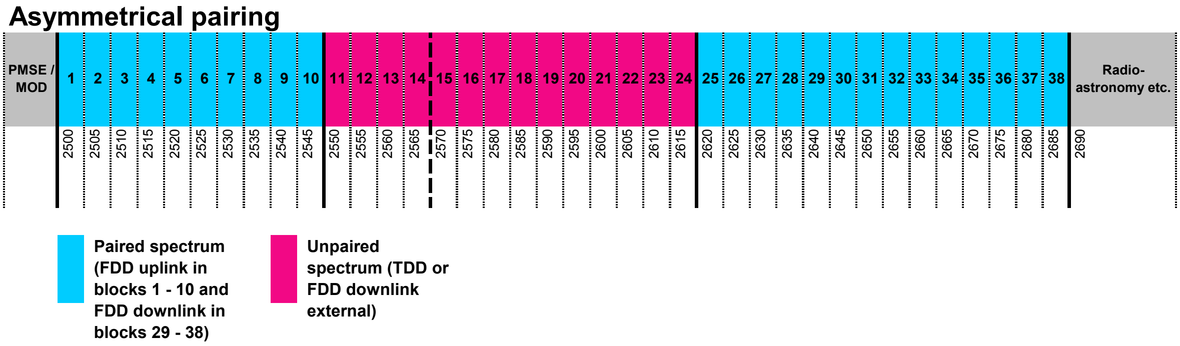
7.41 In the event that the demand for unpaired spectrum completely dominated demand for paired spectrum then the entire band could be converted to unpaired use as illustrated below (with relevant restrictions on the bottom blocks of each unpaired assignment).

Figure 10: Illustration of the case when all spectrum goes to unpaired use in the 2.6 GHz band



7.42 A final consideration which is not discussed in detail in this consultation document is that there may be a demand for asymmetric pairings such as more FDD downlink than FDD uplink. This is illustrated below, however our market analysis has not identified any significant demand for this option and it has therefore not been considered further.

Figure 11: Illustration of the expansion of unpaired spectrum relative to the CEPT band plan without as many uplink paired blocks as downlink paired blocks



Question 10: Do you agree with Ofcom's proposed approach to allowing the respective amounts of paired to unpaired spectrum for the band 2500-2690 MHz to be varied (maintaining the 120 MHz duplex spacing and allowing additional unpaired spectrum, if needed, at the top end of the band)?

Impact of adjacencies between the 2.6 GHz band and neighbouring bands

7.43 Section 5 provides details of the analysis of adjacent band use and paragraphs 5.41 set outs the following conclusions on the implications for the spectrum rights that would be available for award within the 2.6 GHz band.

a) At the 2500 MHz boundary: no special restrictions would be required unless the bottom end of the 2.6 GHz band were to be awarded as unpaired spectrum: in this case, the bottom 5 MHz (2500-2505 MHz) would have to be a significantly restricted block (effectively reduced to pico-cellular powers) and the second channel from bottom (2505-2510 MHz) would have a tightened out-of-band mask. In other cases where the bottom of the 2.6 GHz band is used for FDD, filtering of PMSE equipment may be sufficient to protect PMSE use from FDD terminal use and vice versa.

b) At the 2690 MHz boundary: no special restrictions are required to protect radio astronomy as there is no current or planned use of the 2690-2700 MHz band and no specific restrictions on use of the 2.6 GHz band are necessary to protect aeronautical radar as the frequency separation and proposed out-of-band mask is considered sufficient. The risk of interference from aeronautical radars into the 2.6 GHz band is unlikely to be significant.

7.44 Section 9 provides the details of the proposed transmission rights and associated spectrum masks.

7.45 The different nature of adjacencies at the two boundaries means that it would be more efficient to add additional unpaired / TDD blocks at the top end of the 2.6 GHz band, if additional unpaired spectrum is required, rather than at the bottom end of the 2.6 GHz band. This is because there would be no need to restrict an additional channel to manage interference with adjacent users at the top of the band.

Impact of adjacencies between new uses within the 2.6 GHz band

7.46 There are essentially two ways in which we expect the spectrum in the 2.6 GHz band to be used, paired and unpaired. Paired spectrum is used for systems that use frequency division duplex (FDD). Unpaired spectrum can be used for time division duplex (TDD) or for unidirectional services such a broadcasting.

7.47 Paired use (FDD) is based on the use of two distinct types of frequency blocks to operate and there generally needs to be a minimum frequency separation (or “duplex spacing”) between the two types of blocks. Network base stations will transmit to user terminals (such as handsets) in particular frequency blocks referred to as downlink blocks and user terminals will receive on those frequencies. User terminals will transmit to network base stations in different frequency blocks referred to as uplink blocks and network base stations will receive on those frequencies.

7.48 Unpaired use (TDD or unidirectional) is based on a single type of frequency block to operate. Network base stations transmit and receive on the same frequency. Similarly, if and when they need to, user terminals transmit and receive in the same frequency blocks as the network base stations. The ability to use the same frequency for transmit and receive is achieved by placing these signals in different time slots (essentially, a burst of downlink in one timeslot is followed by a burst of uplink in the following timeslot).

7.49 For mobile systems, where a fixed base station can be in communication with a number of mobile handsets, transmission from the mobiles is called the uplink and transmission from the base station is called the downlink. In FDD systems the uplink is usually on a lower set of frequencies and the downlink on a higher set. The distance between an uplink frequency and the associated downlink frequency is referred to as the duplex spacing. The reason for separating uplink and downlink either in terms of frequency or time is so that a base station’s or mobile’s transmissions do not cause interference to their own receiver.

7.50 Where two operators occupy adjacent spectrum there is potential for out-of-band interference from the transmissions of one operator to affect its neighbour[99]. Where the two operators both operate FDD systems then interference between terminals[100] and interference between base stations is unlikely to be a problem. This is because they transmit and receive on different frequencies, therefore equipment operating in adjacent frequencies operate at similar powers (adjacent terminals transmit at lower powers at uplink frequencies and receive the higher powers of base stations at downlink frequencies while adjacent base stations transmit at higher powers at downlink frequencies and receive the lower powers of terminals at uplink frequencies).

7.51 For a FDD operator with a TDD neighbour, or for two TDD neighbours, then transmitters and receivers will be on adjacent frequencies and there is a high probability that they could interfere with each other[101]. This is because, in a given timeslot, a terminal or a base station (whether these are FDD or TDD) may be receiving interference from higher power transmissions of a TDD base station

[99] More detailed information on the issue is included in the technical reports published alongside this consultation document and available at http://www.ofcom.org.uk/consult/condocs/2ghzawards/.
[100] Also referred to as handsets, mobile stations or user equipment.
[101] If the unpaired spectrum was used for unidirectional broadcast, then there would be similar problems when a broadcast channel is adjacent to an FDD uplink channel, or adjacent to a TDD channel. However, there would not be an equivalent interference problem between a broadcast channel and an adjacent FDD downlink channel, or between adjacent broadcast channels.

operating at adjacent frequencies. A traditional way to avoid this problem is to maintain a guard band between the two operators. A guard band is a block of spectrum where transmissions are not allowed and it effectively provides a buffer between two users to avoid them interfering with each other.

7.52 Guard bands effectively sterilise blocks of spectrum and if they are not assigned then they inhibit the aggregation of spectrum via secondary trades. They also make it difficult for licence holders for spectrum either side of the guard band to negotiate with each other to make more efficient use of the spectrum at their boundary.

7.53 Ofcom's preferred approach to the problem of managing interference between different FDD and TDD neighbours is to assign all spectrum up to the boundary (and not to leave a vacant block) but to impose a more restricted transmission mask (or usage rights) in the blocks of spectrum at the boundary than on the rest of the spectrum. Therefore the restricted blocks would be available for assignment in the award.

7.54 Analysis conducted by Ofcom and the Consultants suggest that between each FDD/TDD neighbour and between each TDD/TDD neighbour one 5 MHz block of spectrum needs a restricted transmission mask for base station operation that keeps the usable power down to the equivalent of pico-cellular powers (1 W or less). In addition, for the second adjacent 5 MHz block either side of that restricted block, a modified out-of-band mask for base station operation is also needed (but the in-band power is not specifically restricted and is typical high power). Details of these restrictions are provided in section 9.

Question 11: Do you agree with Ofcom's proposals for a 5 MHz restricted block between FDD and TDD neighbours and between TDD and TDD neighbours and with a modified out-of-band base station mask for second adjacent 5 MHz blocks?

Packaging proposals for the 2.6 GHz band

7.55 In light of the above analysis, Ofcom proposes that the award of the 2.6 GHz band be packaged in the following way. The spectrum would be auctioned as either paired or unpaired lots based on 5 MHz blocks. A paired lot would include 2x5 MHz and an unpaired lot would include 5 MHz. The split between paired and unpaired spectrum would be determined in the auction and the 120 MHz duplex separation specified in the CEPT plan would be maintained. If demand for unpaired spectrum, relative to the demand for paired spectrum revealed through the auction, were to exceed that available in the centre gap (the 50 MHz identified in the CEPT plan), additional unpaired blocks would be assigned from the top part of the paired portion of the 2.6 GHz band. Ofcom considers that these proposals will best allow the necessary flexibility for the market to decide on the best use of the spectrum, while maintaining as much compatibility with the CEPT plan as possible. The latter will ensure that terminals built to the CEPT plan can operate in the UK.

7.56 Ofcom notes that an implicit feature of this proposed approach is that all of the 2.6 GHz band would have to be awarded as part of a single award process in order to allow the market to determine the split between paired and unpaired spectrum. This precludes an approach in which an award for the central 50 MHz of unpaired spectrum were to take place at a different time to an award for the 2x70 MHz of paired spectrum.

7.57 The following paragraphs explain the way in which these packaging proposals would handle:

a) the flexibility in allocation between paired and unpaired spectrum;

b) the need for restrictions in use between adjacent applications within the 2.6 GHz band: and

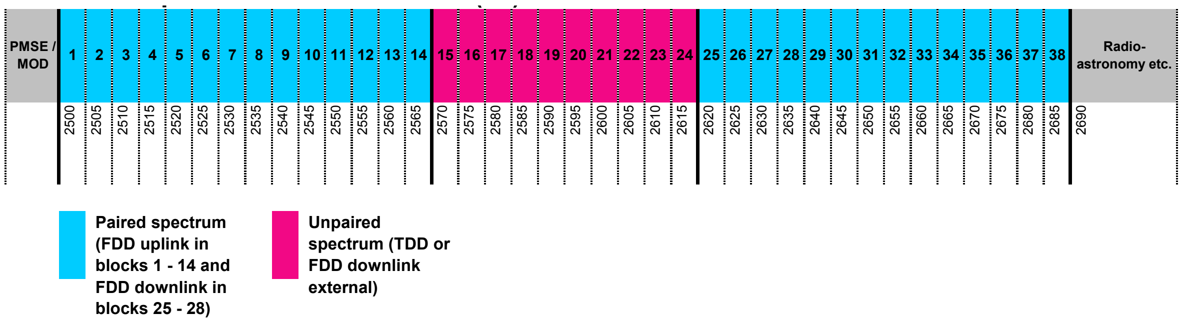
c) the way in which the allocations would address the desire of bidders to be awarded contiguous spectrum.

7.58 There are 38 blocks of 5 MHz available for award in the 2.6 GHz band; these will form the "lots" in an auction. The lots would have either TDD-based usage rights[102] consisting of 1x5 MHz or FDD-based usage rights consisting of 2x5 MHz (there will also be a limited number of blocks that have very restricted usage rights as explained in paragraph 7.61 below). The blocks of 5 MHz are labelled channel 1 to channel 38 in figure 12 below which represents the reference case in which the split between paired and unpaired is as per the CEPT plan. The exact number of lots available for TDD or FDD use depends on how the spectrum is divided up between paired and unpaired use: but in this reference case there are:

- 9 unpaired lots of 1x5 MHz with TDD-based usage rights (the minimum is 9 lots, rather than 10 lots, because channel 24 would be designated as a restricted block as explained in paragraph 7.61 below); and

- 14 paired lots of 2x5 MHz, with 120 MHz separation and FDD-based usage rights.

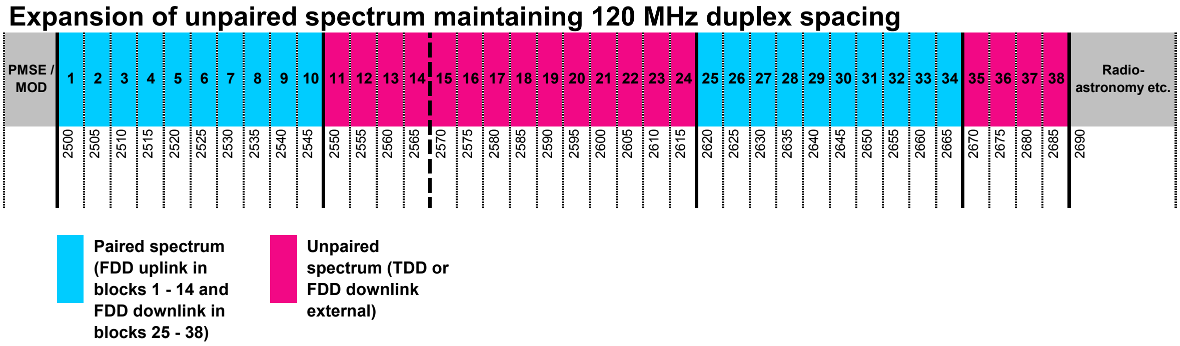
Figure 12: reference point for the available spectrum in the 2.6 GHz band in the proposed award



7.59 If demand for unpaired lots in the auction is sufficient to displace some paired lots, then the boundary between the two types is shifted downwards from 2570 MHz, creating additional unpaired spectrum at the expense of paired uplink spectrum, as illustrated in the example in figure 13 below in which four FDD lots have been displaced (channels 11 to 14 in this example). This has the effect of also freeing up corresponding paired downlink spectrum at the top of the band below 2690 MHz, allowing the creation of further unpaired lots (channels 35 to 38 in this example).

[102] Note that TDD-based usage rights will accommodate unidirectional broadcasting; they will also accommodate FDD downlink usage (e.g. to allow a channel which is unpaired within the 2.6 GHz band to be paired externally)

Figure 13: Illustration of the proposed way to allow expansion of unpaired spectrum in the 2.6 GHz band depending on relative demand for paired and unpaired spectrum



7.60 Typically, for each paired lot that is removed, an additional two unpaired lots can be created, one in the lower part of the band and one in the upper part of the band. There are two exceptions to this rule.

- In the case that only one paired lot is converted to unpaired, then there would not be sufficient spectrum in the upper band to be able to use this for TDD or broadcast-type applications and have an adequate separation from adjacent paired use. This is because a significantly restricted block is required at that adjacency as explained in paragraph 7.61 below.

- In the case that all spectrum is awarded to unpaired use, then there is no longer a requirement for a 'restricted block' (see paragraph 7.61 below) between paired and unpaired in channel 24. In this case, an additional unpaired block can be awarded.

7.61 In order to prevent harmful interference between adjacent unpaired/TDD applications it is necessary to have a 5 MHz separation ('restricted block') between them. An equivalent 5 MHz separation ('restricted block') is required where an unpaired/TDD application is adjacent to a paired/FDD application. No separation is required between adjacent FDD applications. The restricted blocks are taken out of the unpaired lots[103] as follows.

a) Lot 24, at 2615-2620 MHz, would be designated as a restricted block (i.e. not available for full power TDD or FDD use)[104] since it will represent a paired/unpaired boundary and require corresponding restrictions in all cases except where the whole 2.6 GHz band is awarded as unpaired lots.

b) For each winner of unpaired lots, the lowest frequency lot that they are awarded would be subject to specific usage restrictions designed to protect adjacent unpaired or paired use. For example if a bidder wins three unpaired lots, the

[103] This preferable to taking restricted lot out of paired spectrum because there needs to be a restricted block between two TDD assignments; if restricted blocks were taken from paired spectrum, two blocks of 5 MHz would be affected instead of one while that could not provide protection between bidders for unpaired spectrum; and if restricted blocks were taken from paired spectrum, there would be differences between bidders for unpaired spectrum, some having restricted lots and others not.
[104] Although block 24 would not be included in the main part of the auction, it might still be possible for one of the adjacent users to make some use of this block. Section 8 and Annex 8 on the auction design therefore include proposals for the assignment of block 24 (2615-2620 MHz) at the end of the auction process.

lowest one in frequency terms would be subject to those specific restrictions while the other two would be useable at typical high powers. This is so that the restricted lot can serve primarily as a guard band[105]. However, some low-power uses may be possible and, subject to negotiation with neighbouring users and a subsequent licence variation, other uses might be possible, for example some high-power use on a geographically limited basis.

c) One further lot between lots 26 and 38 inclusive may also need to be designated as a restricted block in the case where channels at the top of the band are switched to unpaired use (i.e. where the successful demand for TDD exceeds 50 MHz) in order to separate the unpaired spectrum assigned at the top of the band from the paired downlink spectrum. In figure 13 above, this extra restricted block would be at channel 35. Note, however, that this would only be a genuine addition to the number of restricted blocks if there is a winning TDD bidder that receives a split assignment with some unpaired spectrum in the middle block and some unpaired spectrum in the top block. Using the example in figure 13 again, if a successful TDD bidder was awarded 4 unpaired lots from lot 35 to 38, then lot 35 would already be restricted under point (b) above.

7.62 A consequence of point (b) above is that there is no point in allowing bidders to submit bids for only one unpaired lot as this lot would be encumbered by the additional restrictions to prevent interference to adjacent use. Beyond the minimum of 2 unpaired lots, bidders could express a demand for any number of unpaired lots (e.g. they can express demand for 2 lots, or for 3 lots or for any number up to 38 lots). Bidders for paired lots may bid for one or more paired lots of 2x5 MHz each, up to a total of 14 lots. Bidders could also bid for combinations of the two categories of lots in the 2.6 GHz band: paired lots of 2x5 MHz and unpaired lots of 5 MHz.

7.63 The way that the packaging arrangements are translated into auction rules can ensure, with one possible exception, that winning bidders would be awarded contiguous spectrum.

- Winning bidders that win more than one paired lot would always be awarded paired contiguous spectrum (i.e. contiguous uplink blocks paired with contiguous downlink blocks with a duplex spacing of 120 MHz).

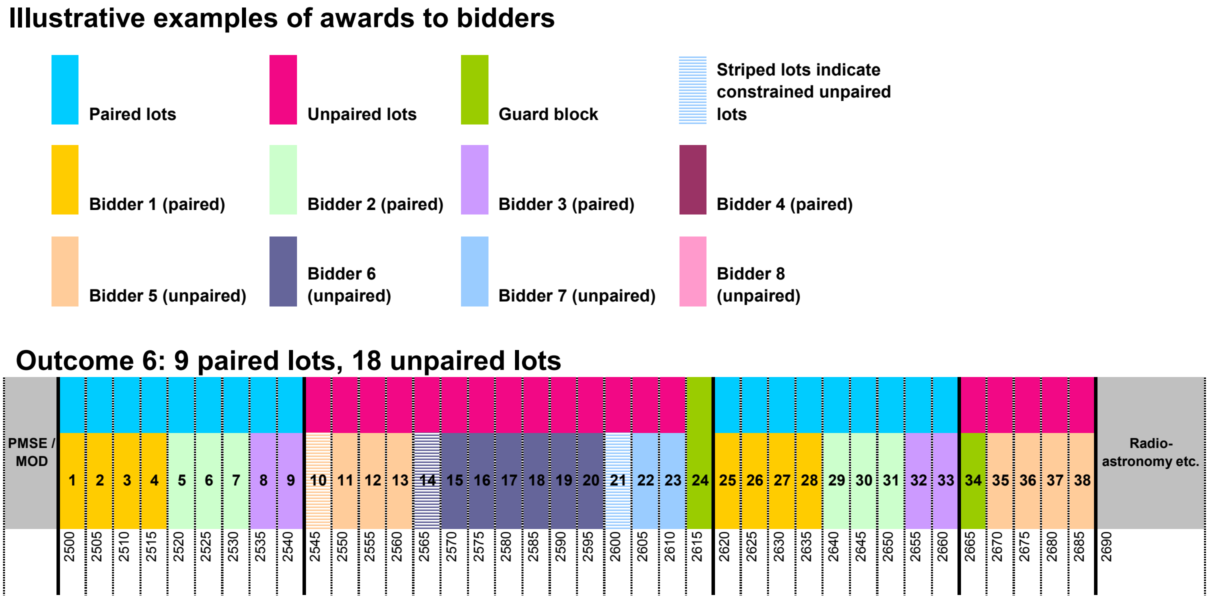
- Winning bidders for unpaired lots would normally be awarded contiguous spectrum. However, it is possible that one winner of unpaired spectrum, and one at most, may need to receive spectrum in two separate blocks (a split assignment), one block in the centre portion of the band and another at the top end of the band. In this case, each of its two blocks would consist of at least two contiguous lots. It is not inevitable that a split award of this type would be required; in particular, it might be possible to fit all winning bidders for unpaired spectrum into either the centre band or the top band of unpaired channels (in figure 13, for example, a bidder winning 4 unpaired lots could be fitted into channels 35 to 38 thereby avoiding the need for a split allocation). The rules for achieving these outcomes are discussed in section 8 (and annex 8).

7.64 An example of the allocation of contiguous spectrum is illustrated in Figure 14 below, which includes a split assignment of unpaired spectrum. In this example, the relative demands for paired and unpaired lots are such that the amount of unpaired spectrum

[105] Using the outcome in Figure 13 as an example, channel 11 would be restricted in this way and if different TDD bidders won channels 11 to 13 and 14 to 19, then channel 14 would also be restricted etc.

has increased compared to the 50 MHz in the reference case. Five additional lots of 5 MHz are won for unpaired use at the top end of the band.

Figure 14: example of award outcome with 6 winning bidders and including a split unpaired assignment



7.65 In this example, three bidders win paired contiguous spectrum.

- Bidder 1 wins 4 paired lots (4x2x5 MHz).
- Bidder 2 wins 3 paired lots (3x2x5 MHz).
- Bidder 3 wins 2 paired lots (3x2x5 MHz).

7.66 Three bidders win unpaired spectrum.

- Bidder 5 wins 8 unpaired lots (8x5 MHz). The assignment is split and includes two separate parts of contiguous spectrum. The lower block includes a restricted block of 5 MHz at the bottom of its assignment (block 10 at 2545-2550 MHz) to avoid interference to the user below.
- Bidder 6 wins 7 unpaired contiguous lots (7x5 MHz). This includes a restricted block of 5 MHz at the bottom of its assignment (block 14 at 2565-2570 MHz) to avoid interference to the user below.
- Bidder 7 wins 3 unpaired lots (3x5 MHz). This includes a restricted block of 5 MHz at the bottom of its assignment (block 21 at 2600-2605 MHz) to avoid interference to the user below.

7.67 There are two restricted channels that would be held back in the first stages of the auction (but which, as described in section 8 and Annex 8, would be available for award in the last stage of the auction process):

   o channel 24 at 2625-2630 MHz; and

- o a restricted channel of 5 MHz that is introduced because of the need for a split award for bidder 5 (as explained in paragraph 7.63); this additional restricted channel is positioned at channel 34 (2665-2670 MHz).

7.68 Drawing together the above proposals, Table 1 below provides a list of the 15 possible outcomes for the 2.6 GHz band in terms of the amounts of spectrum for paired use and unpaired use. It also identifies whether one or two restricted blocks (“guard blocks”) may need to be held back in the first stages of the auction.

Table 1: list of the potential award outcomes in terms of amounts for paired and unpaired spectrum in the 2.6 GHz band

Outcome	TDD lots (1x5MHz)					FDD lots (2x5MHz)			‘Guard blocks’	
	Total no. of lots	Lower band		Upper band		Total no. of lots	Uplink	Downlink	No. of lots	Frequencies
		No. of lots	Frequencies	No. of lots	Frequencies					
1	9	9	2570-2615	0	-	14	2500-2570	2620-2690	1	2615-2620
2	10	10	2565-2615	0	-	13	2500-2565	2620-2685	2	2615-2620 & 2685-2690
3	13*	11	2560-2615	2*	2680-2690	12	2500-2560	2620-2680	1†	
4	15*	12	2555-2615	3*	2675-2690	11	2500-2555	2620-2675	1†	
5	17*	13	2550-2615	4*	2670-2690	10	2500-2550	2620-2670	1†	
6	19*	14	2545-2615	5*	2665-2690	9	2500-2545	2620-2665	1†	
7	21*	15	2540-2615	6*	2660-2690	8	2500-2540	2620-2660	1†	
8	23*	16	2535-2615	7*	2655-2690	7	2500-2535	2620-2655	1†	
9	25*	17	2530-2615	8*	2650-2690	6	2500-2530	2620-2650	1†	2615-2620
10	27*	18	2525-2615	9*	2645-2690	5	2500-2525	2620-2645	1†	
11	29*	19	2520-2615	10*	2640-2690	4	2500-2520	2620-2640	1†	
12	31*	20	2515-2615	11*	2635-2690	3	2500-2515	2620-2635	1†	
13	33*	21	2510-2615	12*	2630-2690	2	2500-2510	2620-2630	1†	
14	35	22	2505-2615	13*	2625-2690	1	2500-2505	2620-2625	1	
15	38	38	2500-2690	na	na	0	-	-	0	

*Actual number of TDD lots would be 1 less than this in the event that there is a TDD bidder that must receive a split assignment.
†Actual number of ‘guard blocks’ would be 1 more than this in the event that a TDD bidder must receive a split assignment.

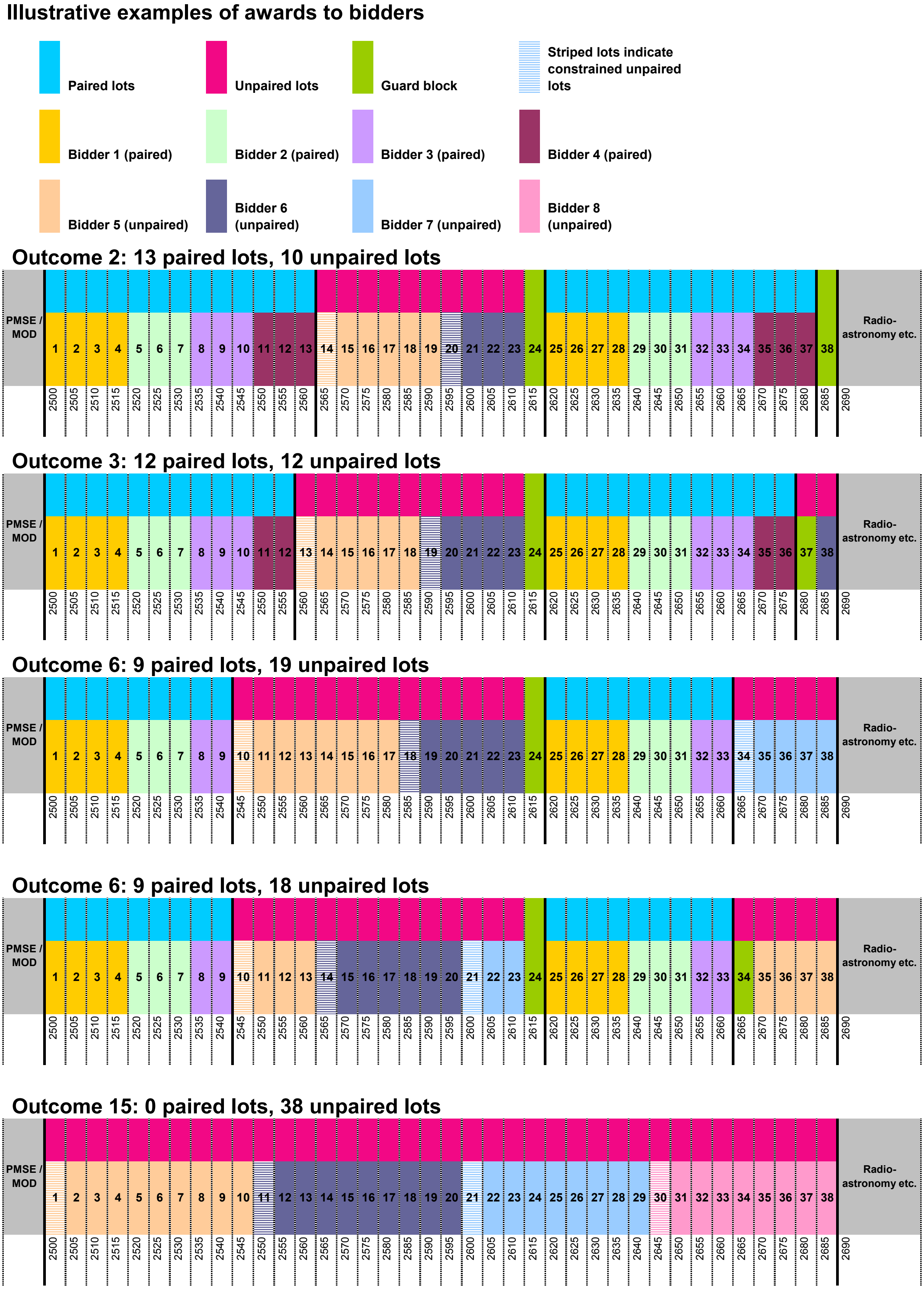
7.69 Figure 15 below then provides further examples of how some of the 15 possible outcomes for paired and unpaired spectrum could turn into assignment allocations to individual bidders. Examples are included for outcome 2 (13 paired blocks and 10 unpaired blocks), outcome 3 (12 paired lots and 12 unpaired lots, including one split assignment), outcome 6 (9 paired lots and 19 unpaired lots), another option for outcome 6 (9 paired lots and 18 unpaired lots, including one split assignment) and outcome 15 (no paired lots and 38 unpaired lots).

7.70 Note the different versions of outcome 6:

- in the first case, it is possible to accommodate the three successful bidders for unpaired spectrum without requiring one of them a have a split assignment. In this case, it is possible to award 19 unpaired lots.

- in the second case, there is no way of assigning unpaired spectrum to the three successful bidders for unpaired spectrum in a way that avoids a split assignment. Hence, an additional “guard block” (or, rather, an additional restricted channel) is held back so that bidder 5 is not required to buy an additional channel with restricted rights as a result of having a split assignment.

Figure 15: illustrations of potential assignments to bidders for some of the 15 possible outcomes in terms of amounts of paired and unpaired spectrum



The 2010 MHz band

Spectrum requirements of candidate uses and technologies

7.71 There appears to be evidence of demand for this spectrum for mobile multimedia (e.g. using MBMS or TDtv), wireless broadband TDD and PMSE. There is also limited evidence of demand to use the spectrum for FDD systems[106]. These potential uses of the band require varying amounts of spectrum of 5 MHz, 10 MHz or 15 MHz. The common feature is that all require spectrum in multiples of 5 MHz.

7.72 In response to the SFR:IP, Kingston Communications was of the view that the 2010 MHz and 2290 MHz bands should be packaged on the basis of 5 MHz blocks, allowing aggregation. Lucent expressed a similar view in respect of the 2010 MHz band.

7.73 For PMSE use there is the possibility that the 15 MHz of spectrum available could be combined with the immediately adjacent 5 MHz block above 2025 MHz to provide two additional 10 MHz carriers for video applications (the 2025-2030 block is MoD spectrum but it is already available to PMSE, although currently unused for that purpose).

7.74 In order to accommodate the most likely uses there are three possible options:

- award the spectrum as three 5 MHz lots;
- award the spectrum as one 10 MHz lot (2010 – 2020 MHz) and one 5 MHz lot; or
- award the spectrum as a single 15 MHz lot.

7.75 Before making a judgement on which of these packaging proposals is likely to be most appropriate, it is necessary to consider the impact of internal adjacencies that might arise if mixed use of the band were to be possible. It is also necessary to consider the impact of adjacencies with neighbouring bands.

Adjacencies between new uses within the 2010 MHz band

7.76 At paragraphs 7.46 to 7.54 we discuss the implication of adjacencies between new uses within the 2.6 GHz band. The conclusions reached for 2.6 GHz are equally valid for the 2010 MHz band. Between each FDD/TDD neighbour and between each TDD/TDD neighbour, one 5 MHz block of spectrum needs a restricted transmission mask for base station operation that keeps the usable power down to the equivalent of pico-cellular powers (1 W or less). In addition, for the second adjacent 5 MHz block either side of the restricted block, a modified out-of-band mask for base station operation is also needed (but the in-band power is not specifically restricted and is a typical high power). The corresponding transmission masks are set out in section 9.

7.77 For smaller bands, such as the 2010 MHz band, there is insufficient spectrum to include such restricted blocks and address adjacencies between internal uses without placing restrictions on a significant proportion of the available spectrum. For example, if there were two users in the available 15 MHz, significant restrictions would apply to 5 MHz and restrictions on out-of-block emissions would apply either

[106] Although less likely, FDD use cannot entirely be ruled out if the demand for paired spectrum in the 2.6 GHz band exceeds the supply of 2x70 MHz. In this event, the 2010 MHz band may be paired with spectrum in the centre block of the 2.6 GHz band in the range 2570-2620 MHz.

side of the restricted 5 MHz block. Ofcom therefore considers that an approach which sought to allow different uses or users in the 2010 MHz band could lead to materially inefficient use of the spectrum.

Impact of adjacencies between the 2010 MHz band and neighbouring bands

7.78 The following paragraphs provide a summary of the adjacency conditions discussed in more detail in section 5.

At the 2010 MHz boundary

7.79 Ofcom intends to respect the conclusions of ERC Report 65 by starting the out-of-band mask 500 kHz upward of the 2010 MHz boundary. No other restrictions are considered necessary.

At the 2025 MHz boundary

7.80 Ofcom intends to respect the conclusions of ERC Report 65 by starting the out-of-band mask 300 kHz inside the 2025 MHz boundary.

7.81 Filtering of PMSE equipment may be sufficient to protect PMSE use from new use in the 2010 MHz band and new uses from adjacent PMSE use. Assuming this is given effect, no other restrictions are considered necessary.

Packaging proposals for 2010 MHz band

7.82 Ofcom proposes to award the spectrum as a single 15 MHz block. Ofcom considers that the need to act cautiously when setting usage right restrictions would mean that the usage rights it would impose for several different blocks to coexist would severely limit the utility of the spectrum. If a single block is awarded, the secondary market offers potential for that single block to be subsequently subdivided through spectrum trading. For example, a potential MBMS user could negotiate conditions under which its services could coexist with those of other users, if possible. They could identify ways of sharing the 15 MHz and trade spectrum accordingly. Ofcom considers that potential competition concerns are not strong enough to suggest not awarding the spectrum as a single 15 MHz block. It is difficult to identify an anti-competitive strategy that is plausible in relation to this band, given that the existing downstream markets that are likely to be most relevant (such as mobile access and origination) are competitive, and that there is a significant quantity of alternative spectrum, including the 2.6 GHz band which is available for award. Moreover, Ofcom has other tools at its disposal were anticompetitive behaviour to occur in a downstream market linked to the use of this spectrum.

7.83 The information available to Ofcom suggests that the 2010 MHz band is a potential substitute for the 2.6 GHz band (e.g. if some bidders were to consider using either 2010 MHz or 2.6 GHz to provide a service) and that the 2010 MHz and 2.6 GHz are potential complements (e.g. if some bidders were to consider pairing parts of the two bands for FDD use or required extra spectrum over and above that available in either band). As discussed further in section 8, Ofcom proposes to award the single lot at 2010 MHz as part of the same process as the award of the 2.6 GHz band, to allow bidders to reflect the potential substitutability and complementarity.

Question 12: Do you agree with Ofcom's proposals to award the 2010 MHz band as a single 15 MHz lot?

The 2290 MHz band

Spectrum requirements of candidate uses and technologies

7.84 There appears to be evidence of demand for this spectrum for PMSE and to a lesser extent wireless broadband TDD. Similar considerations apply to this band as to the 2010 MHz band when deciding upon the most appropriate lot size. For the same reasons as given in paragraph 7.77 above, we propose to offer this band as a single lot of 10 MHz.

Impact of adjacencies between the 2290 MHz band and neighbouring bands

7.85 The results of the technical analysis conducted by Ofcom and the Consultants reached the following conclusions on the impact of adjacencies (see section 5).

a) At the 2290 MHz boundary: no restrictions on typical high power masks are considered necessary for new uses in the 2290 MHz band (see the proposed mask in section 9). Although there is potential for new use in the 2290 MHz band to cause interference into the band immediately below for PMSE and vice-versa, filtering of PMSE equipment may be sufficient to mitigate this risk.

b) At the 2300 MHz boundary: no restrictions on typical high power masks are considered necessary for new uses in the 2290 MHz band (see the proposed mask in section 9).

Packaging proposals for 2290 MHz band

7.86 Ofcom proposes that, of the spectrum band 2290-2302 MHz, only the range 2290-2300 MHz should be made available for award at this point, since demand for the spectrum is very likely to be for a 10 MHz block only. Ofcom proposes to award this spectrum as a single 10 MHz lot.

7.87 The timing of the award of this band relative to the award of the 2.6 GHz and 2010 MHz bands is discussed in section 8 where Ofcom proposes that the 2290 MHz band be awarded separately from, and in advance of, the 2.6 GHz and 2010 MHz bands.

7.88 The appropriate frequencies for a 10 MHz lot would be from 2290 – 2300 MHz. Ofcom proposes that the portion 2300 – 2302 MHz should be held back. This could be awarded alongside the adjacent band 2302 – 2310 MHz at some future date. This band is currently used by the Home Office but is likely to be vacated in the foreseeable future and has been identified in Ofcom's SFR:IP as a candidate band for a future spectrum award[107]. By combining spectrum at 2300-2302 MHz and 2302-2310 MHz, it would be possible to create a new 10 MHz lot, which is likely to allow more scope and benefits for potential users than either lot of 8 or 2 MHz would be by itself.

Question 13: Do you agree with Ofcom's proposals to award the 2290 MHz band as a single 10 MHz lot?

[107] See paragraph 2.68.

Section 8

Auction sequence, formats and rules

8.1 As can be seen in section 6, a core matter on which Ofcom is seeking views (in question 3) is whether or not to authorise the use of the spectrum bands 2500-2690 MHz, 2010-2025 MHz and 2290-2300 MHz. In question 4 Ofcom is also consulting on whether an auction would be an appropriate mechanism for authorising that use, and on timing of any auction. Ofcom has explained its preliminary view that it should proceed with an award as soon as practicable.

8.2 In the light of that preliminary view Ofcom has undertaken further work on what award mechanism might be appropriate. It appears to Ofcom to be valuable to seek views on this aspect too at this time. However Ofcom acknowledges that decisions on the core questions on authorising the use of the spectrum bands by auction can only be made after a detailed review of responses to this consultation exercise.

8.3 Any decision which Ofcom ultimately makes to authorise use and to hold an auction for licences for the use of these bands will be given effect by a statutory instrument (regulations) made under Ofcom's powers under the Wireless Telegraphy Act 1998 (soon to be consolidated in the Wireless Telegraphy Act 2006). Ofcom has to date completed two auctions of spectrum, for the bands 1781.7-1785 MHz paired with 1876.7-1880 MHz and the bands 412-414 MHz paired with 422-424 MHz and the regulations made to give effect to those decisions are available from the website of the Office of Public Sector Information[108].

8.4 In awarding spectrum, Ofcom's aim is to ensure that so far as possible it facilitates the achievement of the award objectives outlined in section 6. In general, how much someone is willing to pay for spectrum is likely to be the best guide to who can use the resources most efficiently. An auction can be a robust way to elicit this information, and Ofcom considers that in general it is likely to be superior to alternative mechanisms such as beauty contests or assigning on a 'first come first served' basis, as discussed in section 6.

8.5 Policy makers have a number of choices at their disposal in defining how an auction should be designed. They have to set both the format of the auction and design the rules for running the auction and deciding on the winners. The choice of auction rules will often depend upon the format chosen. The format and rules of the auction covers issues such as whether:

- bidders can see each others' bids (called an open auction) or whether each bid is secret (sealed bid auction);
- bidders can bid for all lots at the same time or for one lot after the other (simultaneous vs. sequential bidding); and

[108] See Statutory Instrument 2006 No. 338 in respect of the award of 1781.7-1785 MHz paired with 1876.7-1880 MHz, available at http://www.opsi.gov.uk/si/si2006/20060338.htm, and Statutory Instrument 2006 No. 1806 in respect of the award of 412-414 MHz paired with 422-424 MHz, available at http://www.opsi.gov.uk/si/si2006/20061806.htm.

- bidders place bids on each item separately, or on combinations of items (known as package or combinatorial bidding).

8.6 This section begins with an overview of a number of practical considerations that influence the choice of auction design. It then considers the linkages in the award of the three bands, and their sequencing, leading to Ofcom's proposals that:

- the 2.6 GHz and 2010 MHz bands should be awarded together; and

- the 2290 MHz band should be awarded separately and in advance of the other two bands.

8.7 This section then considers the choice of auction design for the two proposed awards, firstly for the proposed combined award of the 2.6 GHz and 2010 MHz bands, and then for the proposed award of the 2290 MHz band. The proposed combined award of the 2.6 GHz and 2010 MHz bands raises a far more extensive set of issues in respect of auction design than does the award of the 2290 MHz band. The bulk of this section is therefore devoted to the first of theses two proposed awards. The analysis of auction design for the 2.6 GHz and 2010 MHz bands sets out a number of key choices in selecting an auction format, given the characteristics of each band and the nature of the potential demand for spectrum in each band. Ofcom's view in respect of each of these design options are then summarised, before setting out a fuller description of Ofcom's proposals for auction design and for other auction rules. A more detailed analysis of the auction format options proposed and a description of the detailed auction rules are provided in Annex 8.

Practical concerns influencing auction design

8.8 An auction may produce more or less efficient outcomes depending on the details of the auction design and the context within which the auction takes place. The economic literature on auctions suggests that in auction design, as in other areas of regulatory policy, it is especially important to address issues such as encouraging participation in the auction and reducing the potential for collusive behaviour.

- There may be asymmetries between potential bidders in the auction, as a result of differences in their current market position, or in the information available to them about the market, or because of differential access to finance (possibly as a result of capital market inefficiency). This may encourage perceptions that some bidders (e.g. incumbent operators) are 'strong' and others (e.g. prospective entrants) are 'weak', even if in some cases, a 'weak' bidder might have the strongest business case. Where asymmetries are significant, weak bidders may be reluctant to invest time and effort in entering the auction, thus making the auction less competitive and effective than it might have been. Auction theory and practice has demonstrated that open, multi-round auctions can discourage entry by 'weak bidders', who fear that they will simply be overbid until they lose. By contrast, the use of sealed bids and/or restrictions on transparency can help to ease the impact of asymmetries, as 'weak' bidders perceive themselves to have a better chance of winning.

- Some auction designs may be vulnerable to strategic behaviour by bidders attempting to influence the auction outcome in their favour. For example, (especially in auctions with pricing rules other than 'pay what you bid') it may sometimes be possible for strong bidders to collude, tacitly or otherwise, to fix the number of licences or influence the price that they pay. Similarly, in multiple round auctions, it is sometimes possible for bidders to use their bids to signal their intentions to each other, creating potential scope for tacit collusion to share resources or to restrict purchase prices.

8.9 A further potential characteristic of bidders that requires consideration when designing the format of an auction is where bidders have a high degree of common value uncertainty on licences[109]. Common value uncertainty could potentially expose bidders to the problem of 'the winner's curse'. This arises because the bidders who over-estimate the value of licences in a common value setting are most likely to win. Rational bidders should respond to this problem by reducing their bids relative to their estimates of value. Nevertheless, common value uncertainty can result in inefficient outcomes. For example, variations in bidders' assessments of common value could lead to differences in how they reduced their bids in response to the winner's curse. If these variations are large compared to differences in the true value for bidders, there is a greater probability that a licence may not go to the person who values it most or that the winner still suffers the winner's curse. In addition, winner's curse effects can affect weak bidders more greatly than strong bidders, exacerbating their disadvantages, for example if their perceived weak position leads them to be less conservative in their bidding than those considered as strong (they could then be more likely to overestimate the common value of a licence). Common value uncertainty can be alleviated by using open, multi-round auctions and high transparency, as bidders can learn from the bidding behaviour of competitors and gain further information about the common value of licences during the auction.

8.10 Auction theory also suggests key factors which determine whether lots should be auctioned separately or together, in particular the degree of complementarity (a lot is worth more if won in conjunction with another lot than on its own) and substitutability (a rise in the price of one lot relative to others would lead bidders to prefer other lots). In the wider sense these issues affect whether the auction of spectrum in the three bands should be combined or separate. In a narrow sense it also affects whether, within any one band, lots should be awarded simultaneously or sequentially.

8.11 If substitutability and complementarity are high, bidders may potentially be exposed to substitution and aggregation risks, respectively. Substitution risk refers to the risk that a bidder may win one lot (or group of lots) when, at the prevailing prices, it would have preferred to win another lot (or group of lots instead) instead. Aggregation risk denotes the risk that a bidder may win a lot (or lots) but fail to win complementary lots. As a result, if either or both risks are present, a simultaneous auction may be more efficient, and there will be implications for other aspects of the auction design.

8.12 Conversely, if substitutability and complementarity are low, the efficiency of the auction is unlikely to be affected by whether licences are sold simultaneously or separately.

Linkages in the award for the three bands

8.13 Ofcom has considered the degree of substitutability and complementarity between the three bands, 2010-2025, 2290-2300 and 2500-2690 MHz. The 2290 MHz band appears to have several significant differences to the other two bands which imply that its substitutability and complementarity with the other bands is low (with the possible exception of demand from PMSE users, discussed below). Firstly, the amount of spectrum available is likely to be insufficient for one of the major potential uses of the 2.6 GHz and 2010 MHz band, mobile broadband wireless. Secondly, because the band is not harmonised or available internationally, were equipment to

[109] See annex 8 for more detail on the issue of common value uncertainty.

be available it would likely be on much less favourable terms than for the other two available bands. The level of demand for the 2290 MHz band for services other than PMSE is therefore likely to be low.

8.14 For PMSE, the 2290 MHz band could be a substitute for the 2.6 GHz band or the 2010 MHz band. However in practice, PMSE bidders may rate their chances of winning in the 2.6 GHz auction as low. Therefore, in practice, the potential substitution risks for PMSE bidders appear to be low.

8.15 As a result Ofcom proposes that the 2290 MHz band should be awarded separately from the two other bands, as part of a distinct award process. Ofcom proposes that this band is auctioned prior to the other bands, principally to account for the remaining potential complementarity and / or substitutability with the other two available bands and allow parties interested in the 2290 MHz band to have the information on the award outcome to consider their position in respect of the award of the 2.6 GHz and 2010 MHz bands. Moreover, the process for auctioning the other bands is likely to be more complex, therefore if the 2290-2302 MHz band could be auctioned earlier with reduced complexity, it would be beneficial to do so.

8.16 The 2010-2025 and 2500-2690 MHz bands appear to be substitutable to some extent although it is difficult to assess this precisely. For example, WiMAX operators may prefer the 2500-2690 MHz band if the 15 MHz available at 2010-2025 MHz is insufficient for their requirements. However, some operators may prefer 2010-2025 MHz if they perceive the propagation characteristics to be better at the lower frequency. Moreover 2010-2025 MHz may provide sufficient capacity for a number of other services including multimedia services or mobile broadband wireless. Ofcom also considers that the 2010 MHz band could be a complement to the 2.6 GHz band. For example, bidders may wish to pair the 2010 MHz band with part of the unpaired spectrum in the 2.6 GHz band, or they could wish to obtain further unpaired spectrum in the 2010 MHz band in addition to unpaired spectrum in the 2.6 GHz band to achieve greater capacity. In addition, blocks within the 2.6 GHz band appear to be substitutes for each other, in that, according to Ofcom's demand and market assessment, the minimum lot size that bidders are likely to seek is likely to vary across services (though they are all multiples of 5 MHz). Bidders may also need or prefer contiguous lots.

8.17 Since there is a good possibility that 2010-2025 MHz and the 2.6 GHz band are close substitutes and / or complements, auctioning them separately could create significant substitution risks and aggregation risks. Provided that the auction design for the combined auction does not create opportunities for strategic manipulation, and does not compromise the efficiency of the overall award in doing so, there is a strong argument for auctioning the two bands in a single auction process.

8.18 An example of the potential for strategic manipulation is as follows. A Simultaneous Multi-Round Auction (SMRA) format that allowed switching between the two bands might create opportunities for gaming the auction if 2010-2025 MHz were an inferior substitute to 2500-2690 MHz for at least some bidders. These bidders could park their demand on 2010-2025 MHz in order to preserve more eligibility for 2500-2690 MHz. This would distort pricing signals for 2010-2025 MHz and could allow bidders to manipulate to some extent the outcome for 2500-2690 MHz.

8.19 However, as discussed below and in annex 8, Ofcom considers that there is an appropriate auction design which will lead to an efficient award outcome without creating opportunities for strategic manipulation. Therefore, Ofcom proposes that the 2.6 GHz and 2010 MHz bands are auctioned in a single process.

Question 14: Do you agree with Ofcom's proposals to combine the award of the 2.6 GHz and 2010 MHz bands and to hold the award of the 2290 MHz band separately and in advance?

Auction design options for the 2.6 GHz and 2010 MHz bands

8.20 We now turn to considerations of how best to design an auction for the 2.6 GHz and 2010 MHz bands assuming, for current purposes and pending consideration of the responses to question 14 above, that the 2.6 GHz band and the 2010 MHz band were to be awarded as part of the same auction process. We begin by considering a number of general design options for the choice of auction format; for each of these design options, we draw conclusions on the most appropriate choice of format for the auction of the 2.6 GHz and 2010 MHz bands. We then summarise Ofcom's specific proposals for the format of the auction and the associated auction rules, a more detailed description of which are given in annex 8.

Key choices in selecting auction format

8.21 There are a number of different auction formats that can be used for the award of spectrum. In selecting the appropriate format for the proposed auction of these bands, it is helpful to consider the following key design options in turn:

- single or multiple lots;
- simultaneous or sequential award of lots;
- single round (sealed bid) or multiple rounds (open process with ascending bids);
- Exposure risks, threshold problems and combinatorial (package) bidding;
- generic or specific lots; and
- price clock or bidder nominated prices.

Single or multiple lots

8.22 The issue of how to package the three available bands for award is discussed in detail in section 7. On the issue of lot size, Ofcom's proposals are as follows.

- Ofcom's preference is to award 2010-2025 as a single lot, because we judge that the risk of an inefficient outcome is lower than if the spectrum were to be awarded as three lots.
- For the 2500-2690 MHz band, the evidence very strongly suggests that the spectrum should be auctioned as multiple lots, given the large amount of spectrum available and indications that bidders may only want small portions of the spectrum band. Auctioning lots based on 5 MHz blocks is compatible with all the services and technologies that bidders may want to provide in this band. The two types of lots proposed are paired lots of 2x5 MHz and unpaired lots of 5 MHz.

8.23 Accordingly, the auction of the combined 2.6 GHz and 2010 MHz bands would involve multiple lots, one lot at 2010-2025 MHz, up to 14 paired lots of 2x5 MHz and up to 38 unpaired lots of 5 MHz (see table 1 in section 7). There may also be either one or two "guard bands" (in practice, restricted channels) available in the 2.6 GHz band (see paragraph 7.61); these are not discussed further in this section for simplicity, but Ofcom does propose to award this channel(s) in the last stage of the auction (in a manner described in annex 8).

Simultaneous or sequential award of lots

8.24 If, as proposed, it is decided to award the spectrum as multiple lots, these can be sold either simultaneously (all at the same time) or sequentially (one after the other).

8.25 As mentioned above, an important consideration is the substitutability and complementarity of the different spectrum lots. In the 2.6 GHz band and the 2010 MHz band, multiple lots would potentially be close substitutes and complements.

8.26 The existence of substitutability and complementarity can cause severe problems for bidders in sequential auctions. Participants must bid for one lot without knowing what the price of other substitute lots will be (e.g. substitution risk) or whether they will be successful in winning complementary lots (e.g. aggregation risk). By contrast, a simultaneous approach can allow bidders to manage aggregation and substitution risk across lots.

8.27 A simultaneous award will therefore be appropriate in the case of the auction of 2.6 GHz and 2010 MHz bands.

Single round (sealed bids), multiple rounds (ascending bids)

8.28 Both single round, sealed bid and multiple rounds, ascending bid auction formats are commonly used for assigning radio spectrum. Sealed bids are often favoured for their administrative simplicity and because, where there are significant bidder asymmetries and related concerns about the level of competition in the auction, they can encourage participation. However, in the absence of concerns about the level of competition in the auction, ascending multiple round auctions are considered to produce potentially more efficient outcomes because bidders can obtain further information on the value of lots by observing the behaviour of competitors over the course of the auction, thereby refining their assessment of their requirements and potentially mitigating the winner's curse.

8.29 In situations of common value uncertainty, it is commonly accepted in auction theory and practice that the outcome of the auction will be more efficient if bidders are able to observe the behaviour of their rivals over the course of multiple rounds. There is significant uncertainty over the evolution of demand for many of the potential uses of this spectrum. At the same time, there may be bidders targeting very similar downstream markets, so they will have a high degree of common value uncertainty. Hence, bidders may benefit greatly from being able to observe how their competitors shift demand in response to prices.

8.30 In addition, bidders may face substitution risks in auctions for multiple lots. The SMRA format which allows bidders to switch their demand to different lots in response to changes in relative prices enables bidders to avoid substitution risks. For example, bidders may end up paying a high price for some lots when substitute lots could have been purchased at a lower price[110].

8.31 For the award of the available bands, there is also a particular case for using multiple rounds so that the market can dynamically aggregate information on the allocation of resources. This is because of the uncertainty, as discussed in section 6 and 7

110 If lots are truly generic and auctioned together on this basis, there is no substitution risk.

concerning the relative amounts of paired (FDD) and unpaired (TDD/unidirectional) spectrum that would optimally be assigned in the 2.6 GHz band. To allow the market to determine the amount of paired and unpaired lots in the 2.6 GHz band, it seems necessary to hold a multiple-round process to enable the competing demand for paired and unpaired lots to achieve dynamically an efficient outcome.

8.32 A multi-round process will therefore be appropriate in the case of the auction of 2.6 GHz and 2010 MHz bands.

Exposure risks, threshold problems and combinatorial (package) bidding

8.33 In auctions with multiple lots, bidders seeking aggregations of lots may face an 'exposure' risk (or aggregation risk). This risk arises whenever there are multiple lots that are complementary for some bidders, and those bidders must bid separately for one lot without certainty over whether, and at what price, they might win the complementary lots. In this situation, the bidder faces the risk that it might win only a subset of the lots it requires, which would be inefficient. Further, such risk tends to encourage conservative bidding, which may mean that bidders fail to win the appropriate number of lots even though they may have the highest valuation on those lots.

8.34 The standard Simultaneous Multiple Round Auction (SMRA), where bidders make separate bids on individual lots, allows bidders considerable flexibility to shift demand across lots in response to changes in prices, and thus provides some opportunity for bidders to monitor their exposure risks. However, there is always a risk that as demand for lots diminishes towards the end of an auction, that bidders may become stranded with unwanted lots. There are various ways of adjusting activity rules to increase flexibility for bidders, such as allowing some bid withdrawals or augmented switching[111], but none of these can completely eliminate the exposure problem.

8.35 The most effective solution to the exposure problem is to allow bidders to make 'package bids', i.e. linked bids for multiple lots that are accepted or rejected in their entirety. Overall, experimental evidence has shown that where some bidders have complementary demands, auction formats with package bidding tend to produce somewhat more efficient outcomes than auctions such as conventional SMRAs in which demands for individual lots are unlinked and may be accepted or rejected piecemeal.

8.36 The downside of allowing "package" bidding (or "combinatorial" bidding as it is also known) is that facilitating aggregation for larger bidders needs to be balanced against the risk that smaller bidders, who for example might want only individual lots, may be unable to adequately coordinate their demand to displace such larger bidders – the so-called 'threshold problem'. The problem is that no one bidder interested in only a small amount of spectrum is likely to be able to outbid a bidder interested in a larger amount of spectrum; it is likely to be necessary for an ad hoc coalition of smaller bidders to form through the auction that is collectively able to outbid the larger bidder. A further problem is that there is often an incentive for individual small bidders in

[111] These are two variants of the standard SMRA format. With limited withdrawals, bidders make multiple, independent bids for predefined lots. Bidders can manage aggregation and substitution risks in two ways: by switching their demand between lots whenever they are overbid; or by withdrawing their current high bids, subject to possible penalties. With augmented switching, bidders that withdraw current high bids from lots are obliged to submit a corresponding number of new bids on other lots, but are not otherwise penalised for making withdrawals. For the proposed award, such arrangements would present specific risks, in particular increasing complexity for bidders.

such an ad hoc coalition to seek to “free ride” on the other members of the coalition – i.e. to bid conservatively in the hope that the other members of the ad hoc coalition will pick up a larger share of the cost. Since all members of the coalition are equally likely to face this incentive, there is a risk that they collectively bid less aggressively than a single, large bidder and, therefore, do not win the spectrum even when it would be efficient for them to do so.

8.37 On balance, Ofcom believes that the benefit of avoiding the exposure risk is significantly the more important factor in the case of these particular bands. Therefore, Ofcom proposes to offer combinatorial bidding to allow bidders to express their preferences for combining lots in the different categories in the auction of 2.6 GHz and 2010 MHz. Bidders could therefore bid for-

- specific numbers of paired lots at 2.6 GHz only;
- specific numbers of unpaired lots at 2.6 GHz only;
- the single lot at 2010 MHz only; or
- combinations of the three types of lots (e.g. some unpaired lots at 2.6 GHz and the single lot at 2010 MHz or paired and unpaired lots at 2.6 GHz).

8.38 For clarity, a combinatorial bid for a specific number of paired lots could take the form of a bid for, say, 4 paired lots (and 4 paired lots only: i.e. in this example, the bidder is not making a bid for any combination which has less than 4 lots, perhaps because the bidder’s business plan relies on a minimum of 4 lots being awarded). In addition we note that the existence of three different categories of lots does not introduce aggregation risks. Stated demand for lots in different categories is a package bid that stands or falls in its entirety.

8.39 Other aspects of the auction design can be used to mitigate the ‘threshold problem’ referred to above, to the extent that this problem might exist for these bands. As discussed in more detail later in this section, and in annex 8, Ofcom is proposing a detailed design which maximises incentives on all bidders to bid truthfully in accordance with their valuation of the lots. This includes the proposal to have ‘best-and-final-offers’ step when bidders reduce their demand, which allows all expressions of demand (be they for small or large numbers of lots) to be taken into account when identifying the winning bids.

Generic or specific lots

8.40 Multiple lots can be sold either on a specific or generic basis. With specific lots, bidders place bids for lots at specific frequencies. By contrast, with generic lots, bidders simply specify the number of lots that they want at a given price per lot, without the lots being associated with particular frequencies. The translation of lots won at the “generic” stage of the auction into actual frequencies then needs to take place in a follow-up process.

8.41 The use of generic lots is appropriate if, within a given category of lot, the variation in value between lots for bidders is likely to be modest. Ofcom considers that this is likely to be the case for the proposed categories of lots. For paired lots in the 2.6 GHz band, all blocks of 2x5 MHz with a duplex spacing of 120 MHz are likely to have similar values. For unpaired lots, all 5 MHz blocks are also likely to have similar values[112]. For the 2010 MHz band, there is only one lot so the issue does not arise.

8.42 Use of generic lots is particularly appropriate where bidders are likely to be interested in packages of more than one lot, and where the value of a package has more to do with the characteristics of the packages as a whole, such as the fact that it is a block of contiguous frequencies, than to do with the specific frequencies assigned. In an auction for specific lots there is no guarantee that bidders will win contiguous blocks of spectrum since the result will necessarily depend upon the specific packages that individual bidders choose to bid on. By contrast the auctioneer in an auction for generic lots can guarantee that most if not all bidders will receive contiguous frequencies.

8.43 Accordingly, Ofcom proposes to base the auction design for the 2.6 GHz and 2010 MHz bands on the use of generic lots.

8.44 The follow-up process can take two main forms. Firstly, Ofcom can allocate the winning bids to specific frequencies using a process of random selection, with the restriction that bidders should receive contiguous blocks of frequencies. Secondly, Ofcom could have a competitive follow-up process which allowed bidders themselves to express a preference between lots. The more that there are differences in value between lots, the more effective a competitive approach for the follow-up process would be in achieving an efficient outcome[113]. As discussed later, Ofcom proposes to adopt a limited competitive approach to the follow-on stage “assignment” stage.

Clock price or bidder nominated prices

8.45 In multi-round auctions the prices can be raised between rounds in one of two ways.

- The bidders can raise the price at which they are willing to buy a particular lot, or package of lots.

- The auctioneer can raise the price of each lot and ask bidders to express their level of demand for the lots at the new, higher price. This is referred to as a “clock” auction and the price of each type of lot is called the “clock price”.

8.46 The first approach is typically used in SMRAs with specific lots. The “clock” approach is typically used when auctioning generic lots because it has a number of significant advantages in this case. For example:

- it simplifies the bidder’s task very significantly since bidders need only express demand for their preferred package of lots at each round, rather than having to express different prices for a number of alternate packages in which they might be interested;

- it reduces complexity in the auction rules; in particular, it avoids the need to solve a complex mathematical algorithm in order to establish the identity of the

[112] Ofcom has considered whether the value to bidders for unpaired lots of the centre gap of 50 MHz (2570-2620 MHz) may be significantly greater than the rest of the 2.6 GHz band. The available evidence suggests that this is not the case and that a single category of unpaired lots across the band is appropriate.
[113] At the limit however, there is a point at which differences in value between lots are so significant that it is better to auction specific lots rather than generic ones.

(provisional) winning bids at the end of each round and the starting prices for individual lots in the next round.

8.47 These considerations also make the clock approach particularly helpful for a smaller bidder that may not have the sophistication that is required to take part in a conventional, combinatorial SMRA auction for many lots.

8.48 In light of the above considerations, Ofcom proposes to use a clock price approach for the auction of the 2.6 GHz and 2010 MHz bands.

Auction design proposals for 2.6 GHz and 2010 MHz bands

8.49 The above discussion indicates that the award of the 2.6 GHz and 2010 MHz bands should have the following design features:

- multiple lots with three lot types;
- a simultaneous award process;
- multiple round bidding;
- combinatorial bidding (alternatively referred to as package bidding); and
- generic lots, using a clock process to elicit the level of demand as the prices for each type of generic lot are raised.

8.50 Ofcom considers that the inclusion of the above features in the proposed auction design is appropriate for the award of the 2.6 GHz and 2010 MHz bands. In particular, the combination of these features should:

- provide an efficient way of determining how much paired and unpaired spectrum there should be in the 2.6 GHz band; and
- take account of the various forms of potential demands, for smaller or larger numbers of lots, through a process that is relatively simple and intuitive for bidders and provides incentives for participants to bid in accordance with their valuations.

8.51 Ofcom has drawn on the above analysis to develop proposals for the more detailed auction design. In summary, Ofcom is proposing a two stage process for the award of spectrum:

- a **principal auction stage** which results in the determination of the amounts of spectrum that are allocated to paired use and unpaired use in the 2.6 GHz band, the identity of the winning bidders and the numbers of lots that they receive in each of the three categories; and
- a **final assignment stage**, which will result in the generic lots won in the principal auction stage being converted into assignments at specific frequencies.

8.52 The paragraphs below give an overview of each of these stages, with a fuller analysis and description in annex 8.

Overview of the principal auction stage

8.53 We have described the first stage of the proposed auction design as the “principal auction stage” to reflect its purpose which is to establish:

- the amounts of spectrum that are allocated to paired use and unpaired use in the 2.6 GHz band;
- the identity of the winning bidders; and
- the numbers of lots that each winning bidder receives in each of the three categories of lot.

It is this stage where most of the competitive action between bidders would take place.

8.54 The heart of the proposed principal auction stage is a simultaneous multiple-round combinatorial clock auction – or ‘clock’ auction for short[114]. It is a natural extension of a simple clock auction to the situation where there are a number of different types of lot. This approach recognises the fact that, potentially, bidders may be interested in acquiring combinations of those different types of lot or substituting between types depending on relative price, both of which this format facilitates to achieve efficient outcomes.

8.55 In a simple clock auction, all the lots are of a single type; they are sufficiently close substitutes that bidders would be equally happy to win any one of them. The auction proceeds in rounds, with the auctioneer announcing a price per lot at the beginning of each round (the ‘clock price’, which is the same for all lots), and bidders responding by saying how many lots they would like to buy at that price. As the price announced by the auctioneer increases, demand falls (bidders not being allowed to increase their demand from round to round). Eventually demand falls to the point where it is less than or equal to supply. At this point the auction ends, with the remaining bidders winning the number of lots that they bid for in the final round and paying the final clock price for each lot they win.

8.56 The proposed combinatorial clock auction for the award of the 2.6 GHz and 2010 MHz bands would adopt a similar procedure but with a number of different types of lot on offer, each with its own clock price. That is, for each type of lot, there would be a unitary price at the start of each round (the clock price for that type of lot) and there would be as many clock prices as there are types of lot. In each round, bidders would state the combination of quantities of the different types of lot that they would most like to buy at the stated prices. Prices of types of lots where demand exceeds supply would be increased in the subsequent round. The clock stage of the process would end when demand for each and every type of lot had fallen to be less than or equal to the available supply (number of lots of each type on offer).

8.57 If, at the end of the clock auction, demand had reduced to exactly match supply then all the available lots would be awarded and the auction could proceed to the final

[114] Clock auctions have been used for applications such as allocating CO_2 abatement obligations under the Emissions Trading Scheme in the UK and for selling electricity and gas contracts in Europe. The auction of electricity contracts by EdF, for example, comprises a clock auction with separate clocks for a number of different contract types.

assignment stage described later[115] . However, if it is quite possible that there could be unsold lots at the end of the clock auction (e.g. a bidder which had a minimum requirement for 6 lots might drop their demand from 6 lots to zero in the final round leaving, say, 4 lots unsold). If so, it might be inefficient to conclude the principal auction stage as there could be potential willing users of the unsold lots[116]. To ensure an efficient outcome, the principal auction stage should therefore provide for a subsequent single-round sealed bid 'best and final offers' stage. Even though we would only know if this stage was needed once the clock auction had been completed, it would be important to allow for this possibility in the auction rules.

8.58 The principal auction stage may therefore require two sub-stages:

- the **clock stage** allowing bids on combinations of generic lots within the 2.6 GHz band and (simultaneously) the single 2010 MHz lot; and, in the case where there were unsold lots at the end the clock stage,
- a **best-and-final-offers stage,** again for combinations of generic lots.

8.59 These two sub-stages are described below.

The clock stage

8.60 The clock stage would proceed in rounds as described above. At the beginning of each round the auctioneer would announce a price for each different type of lot. Each bidder would then state the single combination of quantities of each type of lot that they would most like to win at these prices (their most preferred package of lots). The auctioneer would then identify whether total demand for each type of lot exceeded the number of lots of each type available. If there was no excess demand for any type of lot then the clock stage would end. If there was excess demand for any one or more types of lot, then the clock stage would continue with another round. Prices would be increased for those types of lots for which there was excess demand and stay unchanged for other types. Prices could never fall from round to round.

8.61 In order for the clock stage to reveal information progressively about likely market clearing prices, bidders should not be able to hold back until late in the process to make meaningful bids. An activity rule would limit bidders' eligibility to make bids according to their bidding activity in the previous round and so force bidders to make meaningful bids to stay in the process[117]. The most appropriate form of this activity rule would depend on the particular application. In the case of the award of the 2.6 GHz and 2010 MHz bands, we propose that there would be a restriction that a bidder could not increase the number of lots of a particular type that they bid upon (as the two types of lots are not substitutes).

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[115] The combinatorial clock auction determines how many lots of each generic type bidders receive. However, because generic lots are used, a further assignment stage would need to follow the principal auction stage to determine which specific frequencies are received by winners of the generic lots.

[116] A simple clock auction may not produce an efficient outcome by itself, as it may not be possible to sell all the available lots given a uniform price. This cannot be solved simply by subsequently trying to sell otherwise unsold lots at a lower price, as in this case there is no guarantee that the efficient outcome entails bidders being allocated at least the lots they won in the clock stage.

[117] In the case of the first round the maximum number of lots bidders would be allowed to bid for would be determined by the deposit they submitted.

8.62 The clock stage would end at the point where demand for each and every type of lot had fallen to the point where it no longer exceeded the number of lots of that type available. There would be two possible outcomes at this stage.

8.63 If, at this stage, demand exactly equalled supply (the number of lots available) then there is no need to proceed with the best-and-final-offers stage. The bids made in the final round of the clock stage would be the winning bids and the bidders that made them would be the winning bidders. Each winning bidder would receive the combination of generic lots indicated as their most preferred at the final clock prices. Bidders who had dropped out in the course of the clock stage would have already indicated that they were not willing to purchase at the final clock prices. Therefore, the auction would achieve an efficient outcome. As bidders would have been bidding for generic lots, then the auction would proceed directly to an assignment stage.

8.64 If on the other hand demand were less than supply for at least one type of lot then it will be necessary to have a best-and-final-offers stage.

The best-and-final-offers stage

8.65 The best-and-final-offers stage would follow the end of the clock stage. The best-and-final-offers would come from two sources:

- During the course of the clock stage all bidders would be given the opportunity to submit best-and-final-offers within certain limits each time that they reduce their eligibility; and

- Those bidders remaining at the end of the clock stage would be allowed to make further best and final offers.

8.66 The auctioneer would then use these offers, together with all of the bids made in the course of the clock stage, to determine the most efficient allocation of lots.

8.67 During the course of the clock stage, in any round where a bidder decided that they no longer wished to bid for as many lots as they were entitled to, then they would be able to make best-and-final-offer bids within a set of constraints that are described in annex 8. To illustrate the principle, if a bidder reduced its demand and eligibility from, say, 5 lots of unpaired spectrum down to 3 lots of unpaired spectrum in the new round, then it would be given the opportunity to make best-and-final offers on 5 lots of unpaired spectrum and/or 4 lots of unpaired spectrum at any bid price between the last clock price and the new clock price. The making of such ‘best and final’ offers would allow the bidders to identify all packages of lots that they would be happy to win before clock prices rose beyond the point at which they would no longer to willing to bid for these packages[118]. However, such ‘best and final’ offers would play no role in the rest of the clock stage – they would only become relevant if it were ultimately necessary to proceed to a best-and-final-offers stage.

8.68 Similarly, those bidders remaining at the end of the clock stage might value particular combinations of lots more highly than the final clock prices and may value combinations of lots other than the ones they indicated as their most preferred at each round in the clock stage. Allowing the remaining bidders to make further best and final offers would allow them to express the full range of their preferences. Therefore, those bidders who bid for at least one lot in the final round of the clock stage would be eligible to make new best and final bids at this point. Each of these

[118] Bidders cannot make best and final offers above the prevailing clock prices.

remaining bidders would be allowed to submit 'best and final' offers on any and all packages of lots on which they are eligible to bid given their previous bidding activity.

8.69 Note that those bidders who did not bid in the final round will have already expressed their maximum willingness to pay for all the combinations in which they have an interest through their best and final offers made during the course of the clock stage.

8.70 Once the last of the best and final bids have been submitted following the clock stage, the auctioneer would consider all the bids made in the course of the auction (both bids in the clock stage and all the best and final offers) and identify that combination of bids that is of greatest total value, whilst at the same time being a feasible outcome (that is to say including at most one bid from each bidder, and awarding each lot to at most one bidder). This would be the winning combination of bids, and the bidders that made those bids would be the winning bidders[119].

8.71 The auctioneer would also compute the price to be paid by each individual winning bidder according to a 'second price' rule. The characteristics of this second price rule are that:

- the total amount of money to be paid to Ofcom is minimised; but at the same time
- no losing bidder or combination of bidders (including combinations of losing and winning bidders) would, on the basis of their bids, be willing to pay more.

8.72 The main benefit of this pricing rule would be that the winning bidders (collectively) would only have to pay as much as is necessary to beat the losing bidders (which is why we characterise it as a second price rule). In consequence the incentive to 'shade' bids (that is to say to bid less than the spectrum is actually worth to the bidder) should be significantly lower than in the case of a 'pay what you bid' pricing rule. The risk of an inefficient outcome (where the spectrum is assigned to a bidder with a lower valuation than one to whom spectrum is not assigned) should therefore be much reduced. At the same time, the outcome would be fair, in the sense that each bidder would be paying as much as necessary to ensure that no other bidder or group of bidders would be happy to pay more.

8.73 The price determined for each winning bidder through this 'second price' rule is then referred to as a base price for the purpose of the final assignment stage.

8.74 As bidders will have been won generic lots at this stage, the auction would then need to proceed to the final assignment stage.

The final assignment stage

8.75 The final assignment stage would follow the best-and-final-offers stage (or the clock stage if the best-and-final-offers stage is not run). It would be a further single-round sealed-bid process. The purpose of the final assignment stage would be to assign specific frequencies to each winning bidder.

[119] It may appear possible to go straight to this best-and-final-offers stage without the need for a clock stage. However, the clock stage acts as an efficient way of narrowing down the range of possible combinations of generic lots on which each bidder might wish to submit a best-and-final-offers bid. Without this stage, bidders could have to submit bids for a very large number of packages and the computational challenge for the auctioneer in finding the optimal solution would be correspondingly greater. It also reduces the risk associated with common value uncertainty because bidders gain insights into market value from observing the way in which other bidders adjust their demand in response to rising prices as the clock stage progresses.

8.76 The number of generic lots of each type that each winning bidder would have been assigned would have already been determined through the clock stage and the best-and-final-offers stage (if run). But the winning bidders would have had, as yet, had no opportunity to express any preference they may have for specific frequencies within each type of generic lot. The final assignment stage would allow winning bidders to express those preferences and the auctioneer to use those expressions of preference to make the final assignment of specific frequency lots to individual winning bidders.

8.77 The way that this stage would work is as follows.

- The auctioneer would work out all the feasible solutions for the way in which the spectrum could be assigned to the successful bidders in a way that respects a number of constraints (e.g. in a feasible solution, each bidder must be awarded exactly the number of lots of each type that they won in the combinatorial clock stage, their assignment must be contiguous, a split assignment for a winner of unpaired spectrum must be avoided if possible etc).

- The bidders would be presented with the information on what specific assignments they would receive in each feasible solution; they would then have the opportunity to submit a top-up bid to indicate their willingness to pay more for being assigned the specific frequencies in question (e.g. a particular bidder may be presented with four different ways in which the lots he had won were assigned to specific frequencies. If he was indifferent as to the choice between these, then he would offer no top-up bids for any of them. But if one specific option was better for him than the other three, then he could choose to submit a top-up bid for that specific option).

- Following receipt of all the top-up bids, the auctioneer would identify the feasible solution in which the total amount of top-up bids would be maximised bid and announce the resulting assignment of specific frequencies to specific bidders.

8.78 The licence fee to be paid by each winning bidder would then be set equal to the base price computed for that winning bidder at the end of the best-and-final-offers stage in which they won their generic lots, plus any extra amount that they bid to win the particular package of specific frequency lots assigned to them by this assignment stage, as expressed in their winning top-up bid (if any)[120].

8.79 As discussed further in Annex 8, blocks in the 2.6 GHz band which are identified in the packaging as ‘guard blocks’ (block 24 at 2615-2620 MHz and potentially another block between from block 26 to block 38) would become available for assignment in this final assignment stage. Bidders would be invited to express their preference, using the equivalent of a top-up bid, for receiving those blocks as part of their assignment when they can be contiguous to the number of blocks they have won.

Other auction rules

8.80 Annex 8 includes more details on specific characteristics of the proposed auction design.

8.81 The corresponding rules for the auction would include additional provisions to:

- prevent collusion between bidders;

[120] So there would be, in effect, a pay-what-you-bid pricing rule for top-up bids.

- impose constraints on the degree to which bidders could be associated for example by having control on the way a bidder is conducts its business or by holding a certain proportion of a bidder's shares; and

- address the risk of default from bidders by requiring relevant deposits during the auction stages, in proportion with the clock prices and any best-and-final offer or top-up bid made;

- provide for the possibility that a winning bidder could default at the end of the first stage and determine what should happen to the generic lots that such a bidder had won;

- provide for the possibility that there might be ties between bidders in the final assignment stage;

- ensure an appropriate level of transparency, by publishing during the auction the identity of applicants, their eligibility, the clock prices and number of lots bid on by each bidder and full results (including all bids made) at the end of the auction; and

- address the risk of breach of the auction rules by applying penalties, such as forfeiture of deposits, in relevant circumstances.

8.82 Ofcom also proposes to set a reserve price per lot to help deter frivolous bidders from unnecessarily participating. However, it should not be so low as to preclude the participation of potentially efficient users of the spectrum. In the past, for sealed bid processes, Ofcom has used a reserve price of £50,000 per lot. For the 2.6 GHz and 2010 MHz bands, with a multi-round process, there might be a case for increasing the reserve price per lot to allow the auction to proceed more rapidly and avoid unnecessary rounds, although this could also be achieved through the increment in clock prices between rounds.

8.83 As discussed above, an initial deposit would be required from each bidder that would determine their initial eligibility, i.e. the maximum amount of spectrum on which a bidder could bid. The initial deposit would be set as a proportion of the reserve price for each lot. In section 6, Ofcom has raised the question of whether the maximum amount that any bidder could win should be the subject of a safeguard cap.

8.84 At the end of the auction, Ofcom proposes that winning bidders be required to pay 100% of the licence fee (base price determined at the end of the first stage plus top-up price determined in the final stage) before licences are granted.

8.85 Ofcom would reserve the right to award any unsold lot at the end of the auction as part of a distinct process to be held at an appropriate time.

Question 15: Do you agree with Ofcom's proposals for a two-stage auction design for the 2.6 GHz and 2010 MHz bands?

Auction design options for the band 2290-2300 MHz

Auction format

8.86 Ofcom has proposed that this band be auctioned on its own as a single lot comprising the 2290-2300 MHz range for the reasons given at paragraph 7.84. As a result the auction design issue are very much simpler than in the case of the other bands discussed above. Indeed, the only substantive design issue is which of the following two potential auction formats would be most appropriate for this award: a second price sealed bid or an SMRA format.

8.87 Auction theory can demonstrate that there is no difference in terms of efficiency of outcome between the two formats when bidders are symmetric, have private values that are independent of each other and behave rationally. In a second price sealed bid auction, bidders can do no better than bid their true value therefore, even if there is uncertainty over common values, the spectrum should go to the person who values it the most. The winner of the auction can also mitigate the impact of the winner's curse by shading their bid. If bidders are asymmetric e.g. through having differential access to information about the spectrum, either an SMRA or a sealed bid process could be more efficient, depending on the circumstances. However, in the case of the 2290 MHz band, Ofcom considers that bidder asymmetry in terms of access to information about the spectrum is not likely to be significant.

8.88 Some commentators have suggested that in practice bidders may not behave as predicted by theory in second price auctions, and that they bid more than their true value because they do not evaluate the optimal bidding strategy correctly. The academic literature has explored such behavioural irrationality through auction experiments; however different studies have given different results, making it difficult to draw a general conclusion from the literature.

8.89 The deciding factor between the two formats may be the cost of participation. Many of the potential bidders are small organisations. For them it would appear to be significantly less costly to participate in a sealed bid auction than in an SMRA. In particular, the sealed bid auction is likely to take up far less management time.

8.90 Ofcom proposes, therefore, to use a second price sealed bid format for this auction.

Transparency

8.91 There are two aspects of transparency that concern the auction design: transparency in the identities of bidders and transparency in the amounts bid in the auction. Ofcom's policy is to be as transparent as possible in the conduct of auctions, except where it could have a negative impact on the efficiency of the auction outcome.

8.92 Ofcom proposes to make the identity of bidders in the auction known, because it believes there is little opportunity or prospect that bidders could use this information to distort the outcome of the auction, given the prohibitions against collusion that Ofcom plans to apply and which we would expect to be similar to those in previous spectrum auctions.

8.93 Ofcom has the choice of making public all or part of the bids made in the auction. There is an argument for restricting information about the amount bid by the winner. One of the purposes of the second-price rule is to incentivise rational bidders to bid their true valuation. But if their bids were made public it could affect bidders' incentives to bid their true value if this information was of strategic or commercial importance. This could be particularly relevant in the context of the subsequent auction for the 2.6 GHz and 2010 MHz bands since there is a possibility that some bidders for 2290 MHz may be interested in using 2.6 GHz or 2010 MHz for similar purposes. The amounts bid in the auction of the 2290 MHz band could therefore be sensitive information for certain bidders in respect of the subsequent auction of the 2.6 GHz and 2010 MHz bands. Ofcom therefore proposes to publish only the amount paid by the winning bidder on conclusion of the 2290 MHz auction, and not the amount bid by either the winning bidder or losing bidders. However, Ofcom proposes that, on conclusion of the auction for the 2.6 GHz and 2010 MHz bands, the amounts of all bids in the 2290 MHz auction are published.

Question 16: Do you agree with Ofcom’s proposals to award the 2290 MHz band through a second price sealed bid auction?

Section 9

Regulatory conditions, rights and obligations for wireless telegraphy

Approaches to technical licence conditions

9.1 Within this section, Ofcom sets out proposals on two overall approaches to specifying the technical licence conditions. The first is the transmitter spectrum mask approach which Ofcom has adopted in previous spectrum awards such as 1781.7 – 1785.0 MHz paired with 1876.7 – 1880.0 MHz and 412 – 414 MHz paired with 422 – 424 MHz. The second is the Spectrum Usage Rights (SUR) approach which Ofcom consulted on earlier in 2006[121].

Question 17: Do you have a preference for either of the two approaches to specifying technical licence conditions?

Transmitter spectrum masks

9.2 In general Ofcom is in favour of allowing licensees as much flexibility in the in-band power levels as possible to meet their specific deployment needs for their chosen technology. However, in order to control harmful interference some specific restrictions are necessary particularly where there are adjacencies between different technologies and operators. Additionally out-of-block emissions need to be managed to avoid harmful interference. Below Ofcom has given details of the in-band power and out of-band emissions masks that it considers are the minimum necessary to manage the risk of harmful interference between different users within the three bands under consideration and between users within these bands and users in adjacent bands. The masks have been derived taking into account the most likely uses identified. Where a licensee has contiguous blocks of spectrum the out-of-band emissions from one of their own blocks which fall within their own spectrum assignment is a matter for them to manage and will not be mandated in the licence. Licences will only control out-of-band emissions that fall outside the licensees own spectrum assignment.

9.3 The spectrum masks below are derived from the following 3GPP specifications:

- 3GPP 25.101: Technical Specification Group Radio Access Networks; UE Radio Transmission and Reception (FDD);
- 3GPP 25.102: Technical Specification Group Radio Access Networks; UE Radio Transmission and Reception (TDD);
- 3GPP 25.104: Technical Specification Group Radio Access Networks; BS Radio Transmission and Reception (FDD); and

[121] http://www.ofcom.org.uk/consult/condocs/sur/

- 3GPP 25.105: Technical Specification Group Radio Access Networks; BS Radio Transmission and Reception (TDD).

9.4 The following assumptions have also been used:

- Combined antenna gain and feeder loss for FDD and TDD base stations (except TDD base stations operating on a boundary – see 9.7 below): 17 dB;
- Combined antenna gain and feeder loss of TDD base stations operating on a boundary: 3 dB; and
- Antenna gain of FDD and TDD mobile stations: 0 dB.

Question 18: Do you have any comments on the transmitter spectrum masks defined below?

2500-2690 MHz

Base stations using unpaired spectrum blocks – in band emissions

9.5 As indicated above in section 8, the minimum size of an unpaired spectrum block assigned following the proposed award will be of two 5 MHz lots (or 10 MHz).

9.6 The lowest (in frequency terms) of the lots assigned to each licensee who acquires unpaired spectrum will have its in-band power restricted (roughly equivalent to pico-cellular powers). For all other 5 MHz lots that comprise the unpaired spectrum assignment, a higher in-band power will apply.

9.7 For unpaired 5 MHz spectrum blocks within the 2.6 GHz that are either:

i) adjacent to an paired block in the spectrum immediately below, or

ii) adjacent to an unpaired block assigned to a different licensee in the spectrum immediately below;

the in-band maximum mean EIRP density that may be transmitted from any bases station will be 28 dBm/ MHz.

9.8 For all other unpaired 5 MHz spectrum blocks within the 2.6 GHz band, the in-band maximum mean EIRP density that may be transmitted from any bases station will be 54 dBm/ MHz.

Base stations using unpaired spectrum blocks – out-of-block emissions

9.9 The out-of-block emission mask which applies in the spectrum immediately below the assigned spectrum block will also be restricted (again to the equivalent of that for a typical pico-cell).

9.10 Additionally, the out-of-block mask which applies in the spectrum immediately above the assigned spectrum block will have a restriction in the emissions that can be radiated into the second adjacent 5 MHz block of spectrum. Out-of-band emissions into the first adjacent 5 MHz block of spectrum above will be based on those for a typical macro cell.

9.11 For bases station operating in unpaired spectrum, the following out-of-block emissions in the bands immediately adjacent to the assigned spectrum block will apply:

- the maximum mean EIRP shall not exceed the following mask:

Table 2: 2.6 GHz band – Base Station Out-of-block EIRP Mask (for lower block edge)

Offset from relevant block edge	Maximum mean EIRP
–10.0 to –5.0 MHz (lower edge)	–22 dBm/ MHz
–5.0 to –1.0 MHz (lower edge)	–18 dBm/ MHz
–1.0 to –0.2 MHz (lower edge)	–19 + 15(Δ_F + 0.2) dBm/30kHz
–0.2 to 0.0 MHz (lower edge)	–19 dBm/30kHz
0.0 to +0.2 MHz (upper edge)	+3 dBm/30kHz
+0.2 to +1.0 MHz (upper edge)	+3 – 15(Δ_F – 0.2) dBm/30kHz
+1.0 to +5.0 MHz (upper edge)	+4 dBm/ MHz
+5.0 to +10.0 MHz (upper edge)	–22 dBm/ MHz

Where: Δ_F is the frequency offset from the relevant block edge (in MHz)

9.12 For unpaired spectrum the above in-band power and out-of-band emission mask is shown pictorially in Figures 16 and 17 below:

Figure 16: 2.6 GHz band – Base Station EIRP Spectrum Mask (for lower block edge)

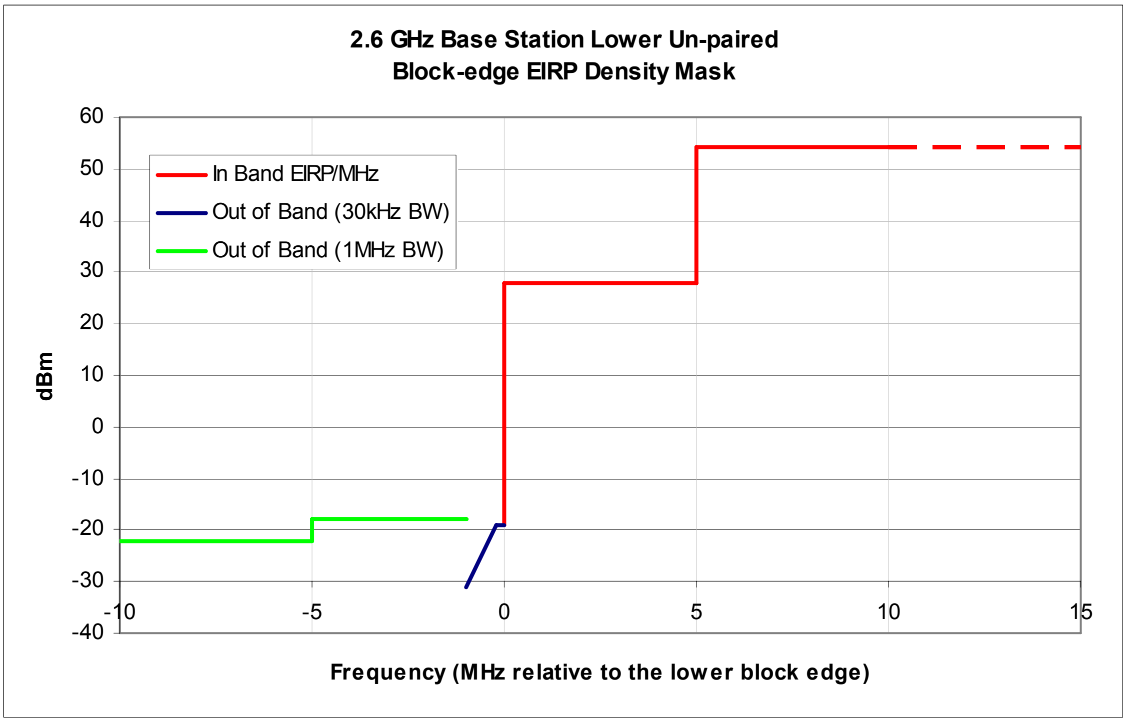
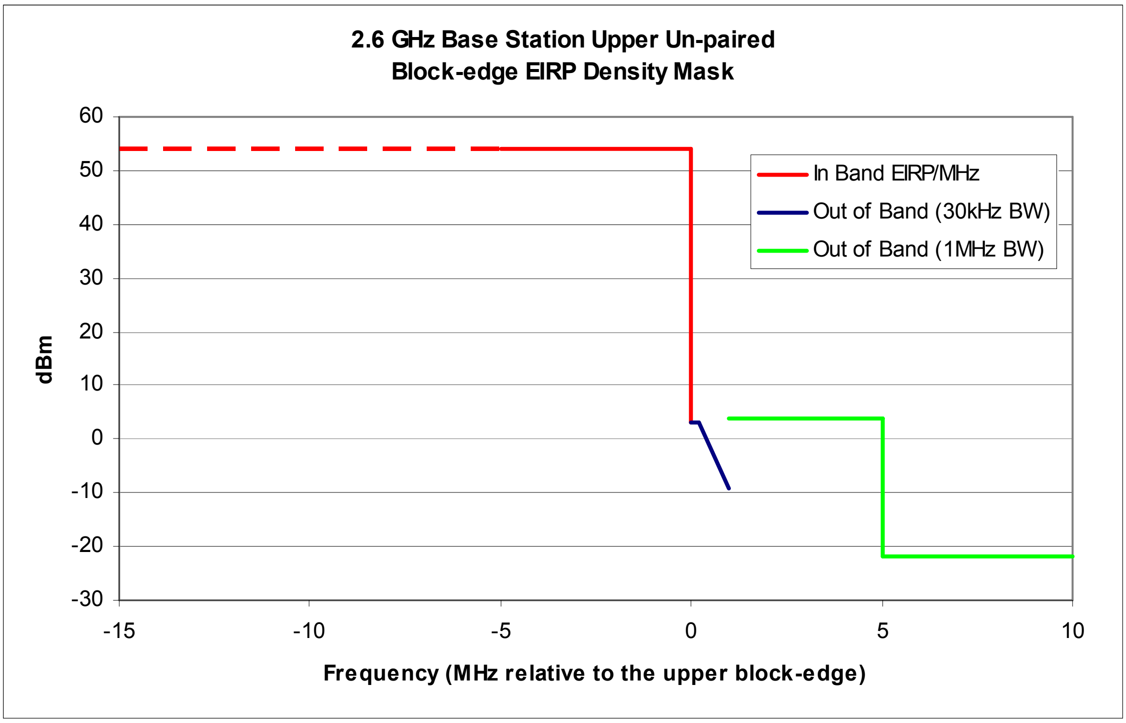


Figure 17: 2.6 GHz band – Base Station EIRP Spectrum Mask (for upper block edge)



Base stations using paired spectrum blocks – in band emissions

9.13 As indicated above in section 8, the minimum size of a paired spectrum block assigned following the award will be a single 5 MHz lot.

9.14 For all paired 5 MHz spectrum blocks within the 2.6 GHz band, the in-band maximum mean EIRP density that may be transmitted from any bases station will be 54 dBm/ MHz.

Base stations using paired spectrum blocks – out-of-block emissions

9.15 For bases station operating in paired spectrum which are not adjacent to an unpaired spectrum block, the following out-of-block emissions in the bands immediately adjacent to the assigned spectrum block will apply:

- the maximum mean EIRP shall not exceed the following mask:

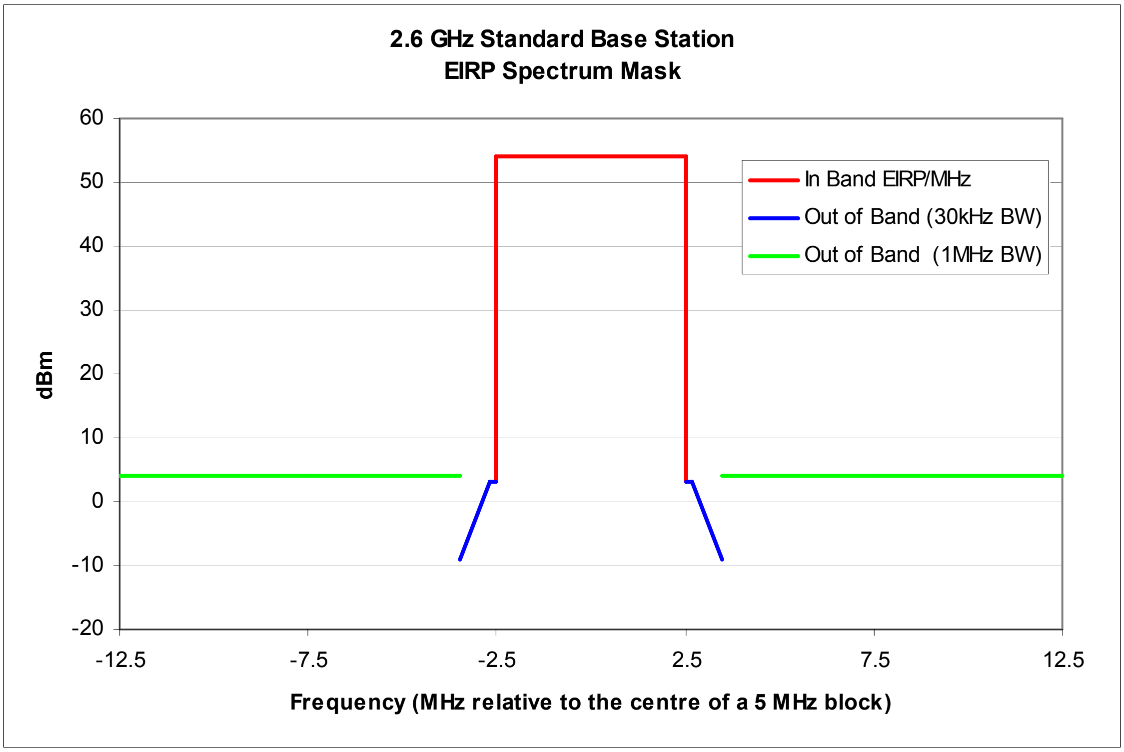
Table 3: 2.6 GHz band – Base Station Out-of-block EIRP Mask for paired spectrum

Offset from relevant block edge	Maximum mean EIRP
–10.0 to –5.0 MHz (lower edge)	+4 dBm/ MHz
–5.0 to –1.0 MHz (lower edge)	+4 dBm/ MHz
–1.0 to –0.2 MHz (lower edge)	+3 + 15(Δ_F + 0.2) dBm/30kHz
–0.2 to 0.0 MHz (lower edge)	+3 dBm/30kHz
0.0 to +0.2 MHz (upper edge)	+3 dBm/30kHz
+0.2 to +1.0 MHz (upper edge)	+3 – 15(Δ_F – 0.2) dBm/30kHz
+1.0 to +5.0 MHz (upper edge)	+4 dBm/ MHz
+5.0 to +10.0 MHz (upper edge)	+4 dBm/ MHz

Where: Δ_F is the frequency offset from the relevant block edge (in MHz)

9.16 For paired spectrum the above in-band power and out-of-band mask is shown pictorially in Figure 18 below (for simplicity it is shown relative to a single 5 MHz block):

Figure 18: 2.6 GHz band – Base Station EIRP Spectrum Mask for paired spectrum



9.17 Where a paired spectrum block is adjacent to an unpaired spectrum block assigned to, the out-of-block mask which applies in the spectrum immediately above or below the assigned spectrum block will have a restriction in the emissions that can be radiated into the second adjacent 5 MHz block of spectrum. Out-of-band emissions into the first adjacent 5 MHz block of spectrum above will be based on those for a typical macro cell.

9.18 For bases station operating in paired spectrum which are adjacent to an unpaired spectrum block in the spectrum immediately above, the following out-of-block emissions in the bands immediately adjacent to the assigned block will apply:

- the maximum mean EIRP shall not exceed the following mask:

Table 4: 2.6 GHz band – Base Station Out-of-block EIRP Mask for paired spectrum (adjacent to unpaired spectrum immediately above)

Offset from relevant block edge	Maximum mean EIRP
–10.0 to –5.0 MHz (lower edge)	+4 dBm/ MHz
–5.0 to –1.0 MHz (lower edge)	+4 dBm/ MHz
–1.0 to –0.2 MHz (lower edge)	+3 + 15(Δ_F + 0.2) dBm/30kHz
–0.2 to 0.0 MHz (lower edge)	+3 dBm/30kHz
0.0 to +0.2 MHz (upper edge)	+3 dBm/30kHz
+0.2 to +1.0 MHz (upper edge)	+3 – 15(Δ_F – 0.2) dBm/30kHz
+1.0 to +5.0 MHz (upper edge)	+4 dBm/ MHz
+5.0 to +10.0 MHz (upper edge)	–22 dBm/ MHz

Where: Δ_F is the frequency offset from the relevant block edge (in MHz)

9.19 For bases station operating in paired spectrum which are adjacent to an unpaired spectrum block in the spectrum immediately below, the following out-of-block emissions in the bands immediately adjacent to the assigned block will apply:

- the maximum mean EIRP shall not exceed the following mask:

Table 5: 2.6 GHz band – Base Station Out-of-block EIRP Mask for paired spectrum (adjacent to unpaired spectrum immediately below)

Offset from relevant block edge	Maximum mean EIRP
–10.0 to –5.0 MHz (lower edge)	–22 dBm/ MHz
–5.0 to –1.0 MHz (lower edge)	+4 dBm/ MHz
–1.0 to –0.2 MHz (lower edge)	+3 + 15(Δ_F + 0.2) dBm/30kHz
–0.2 to 0.0 MHz (lower edge)	+3 dBm/30kHz
0.0 to +0.2 MHz (upper edge)	+3 dBm/30kHz
+0.2 to +1.0 MHz (upper edge)	+3 – 15(Δ_F – 0.2) dBm/30kHz
+1.0 to +5.0 MHz (upper edge)	+4 dBm/ MHz
+5.0 to +10.0 MHz (upper edge)	+4 dBm/ MHz

Where: Δ_F is the frequency offset from the relevant block edge (in MHz)

Mobile Stations – using either paired or unpaired spectrum blocks

9.20 For all paired and unpaired 5 MHz spectrum blocks a within the 2.6 GHz band, the maximum mean EIRP density that may be transmitted from any mobile station in-band will be 24 dBm/ MHz.

9.21 For mobile station operating in unpaired spectrum, the following out-of-block emissions in the bands immediately adjacent to the assigned spectrum block will apply:

- the maximum mean EIRP shall not exceed the following mask:

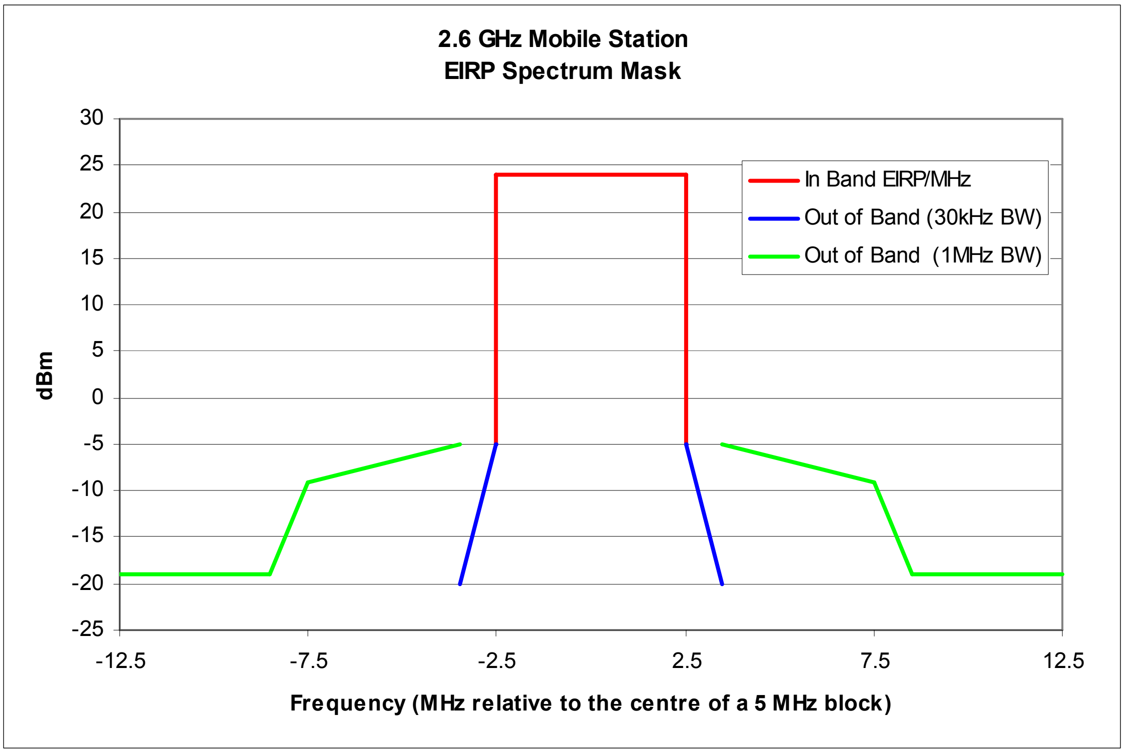
Table 6: 2.6 GHz band – Mobile Station Out-of-block EIRP Mask for paired and unpaired spectrum

Offset from relevant block edge	Maximum mean EIRP
–10.0 to –6.0 MHz (lower edge)	–19 dBm/ MHz
–6.0 to –5.0 MHz (lower edge)	$-9 + 10(\Delta_F + 5.0)$ dBm/ MHz
–5.0 to –1.0 MHz (lower edge)	$-5 + (\Delta_F + 1.0)$ dBm/ MHz
–1.0 to 0.0 MHz (lower edge)	$-5 + 15(\Delta_F)$ dBm/30kHz
0.0 to +1.0 MHz (upper edge)	$-5 - 15(\Delta_F)$ dBm/30kHz
+1.0 to +5.0 MHz (upper edge)	$-5 - (\Delta_F - 1.0)$ dBm/ MHz
+5.0 to +6.0 MHz (upper edge)	$-9 - 10(\Delta_F - 5.0)$ dBm/ MHz
+6.0 to +10.0 MHz (upper edge)	–19 dBm/ MHz

Where: Δ_F is the frequency offset from the relevant block edge (in MHz)

9.22 The above in-band power and out-of-band mask is shown pictorially in Figure 19 below (for simplicity it is shown relative to a single 5 MHz block):

Figure 19: 2.6 GHz band – Mobile Station EIRP Spectrum Mask for paired and unpaired spectrum



2010-2025 MHz

Base stations

9.23 Within ECC Decision (06)01, the position of the upper and lower carriers 5 MHz are described as follows:

- In order to protect users in adjacent bands from harmful interference the carrier nearest to the 2010 MHz boundary must be centred at 2013 MHz or above.
- In order to protect users in adjacent bands from harmful interference the carrier nearest to the 2025 MHz boundary must be centred at 2022.2 MHz or below.

9.24 Ofcom is not proposing to award the band 2010 – 2025 MHz as multiple 5 MHz lots but rather as a single 15 MHz lot. In order to protect adjacent bands from interference, Ofcom proposes to restrict the maximum mean EIRP in the 2010.0 – 2010.5 MHz and the 2024.7 – 2025.0 MHz portions of the available spectrum. The aim is to provide the same effective protection to adjacent services as is provided by ECC Decision (06)01 with regard to UMTS.

9.25 For base stations, the maximum mean EIRP within the 2010 MHz band shall be in accordance with the following mask:

Table 7: 2010 MHz Band – Base Station In-band EIRP Mask

Offset from the lower block edge	Maximum mean EIRP
+0.0 to +0.3 MHz (lower edge)	+18 – 15(0.3 – Δ_F) dBm/ MHz
+0.3 to +0.5 MHz (lower edge)	+18 dBm/ MHz
+0.5 to +14.7 MHz (lower edge)	+54 dBm/ MHz
+14.7 to +14.9 MHz (lower edge)	+18 dBm/ MHz
+14.9 to +15.0 MHz (lower edge)	+18 + 15(14.9 – Δ_F) dBm/ MHz

Where: Δ_F is the frequency offset from the lower block edge (in MHz)
The lower block edge being 2010 MHz

9.26 For bases station out-of-block emissions in the bands immediately adjacent to the 2010 MHz band, the maximum mean EIRP shall not exceed the following mask:

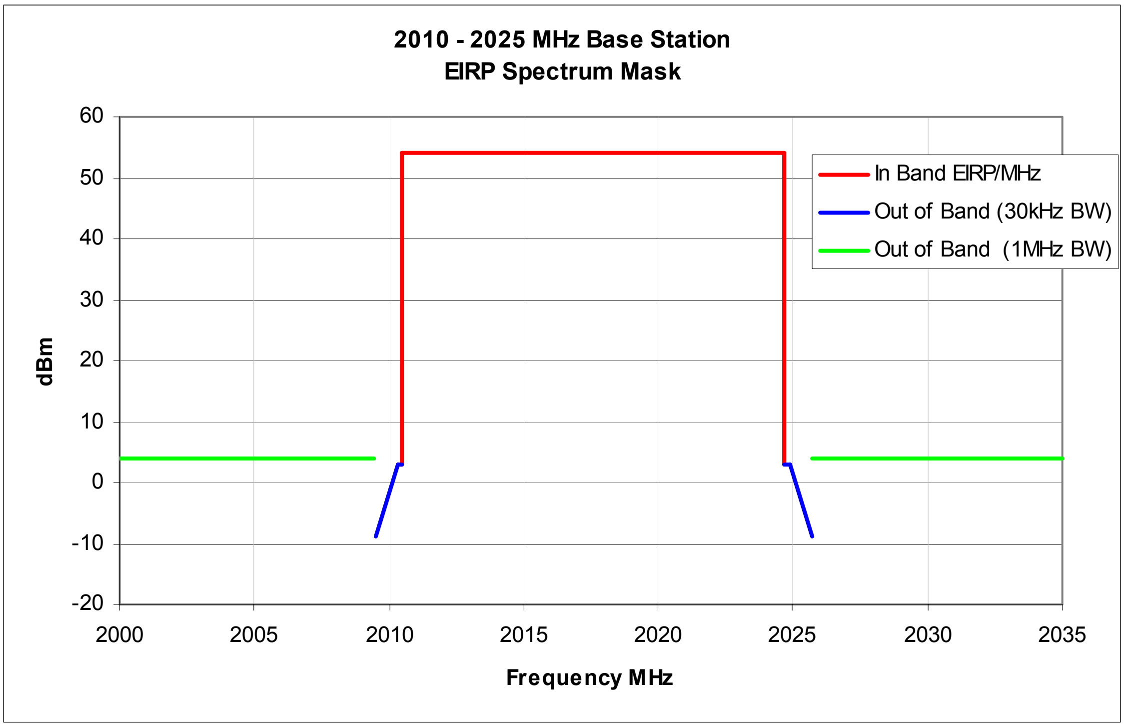
Table 8: 2010 MHz Band – Base Station Out-of-band EIRP Mask

Offset from relevant block edge	Maximum mean EIRP
–10.0 to –0.5 MHz (lower edge)	+4 dBm/ MHz
–0.5 to –0.0 MHz (lower edge)	–1.5 + 15(Δ_F) dBm/30kHz
+0.0 to +0.7 MHz (upper edge)	+1.5 – 15(Δ_F) dBm/30kHz
+0.7 to +10.0 MHz (upper edge)	+4 dBm/ MHz

Where: Δ_F is the frequency offset from the lower block edge (in MHz)
The lower block edge being 2010 MHz
The upper block edge being 2025 MHz

9.27 The above in-band and out-of-band masks are shown in Figure 20 below:

Figure 20: 2010 MHz Band – Base Station EIRP Spectrum Mask



Mobile stations

9.28 As indicated above; in order to protect adjacent bands from interference, Ofcom proposes to restrict the maximum mean EIRP in the 2010.0 – 2010.5 MHz and the 2024.7 – 2025.0 MHz portions of the available spectrum.

9.29 For mobile stations, the maximum mean EIRP within the 2010 MHz band shall be in accordance with the following mask:

Table 9: 2010 MHz Band – Mobile Station In-band EIRP Mask

Offset from the lower block edge	Maximum mean EIRP
+0.0 to +0.5 MHz (lower edge)	+10 – 15(0.5 – Δ_F) dBm/ MHz
+0.5 to +14.7 MHz (lower edge)	+24 dBm/ MHz
+14.7 to +15.0 MHz (upper edge)	+10 + 15(14.7 – Δ_F) dBm/ MHz

Where: Δ_F is the frequency offset from the lower block edge (in MHz)
The lower block edge being 2010 MHz

9.30 For mobile station out-of-block emissions in the bands immediately adjacent to the 2010 MHz band, the maximum mean EIRP shall not exceed the following mask:

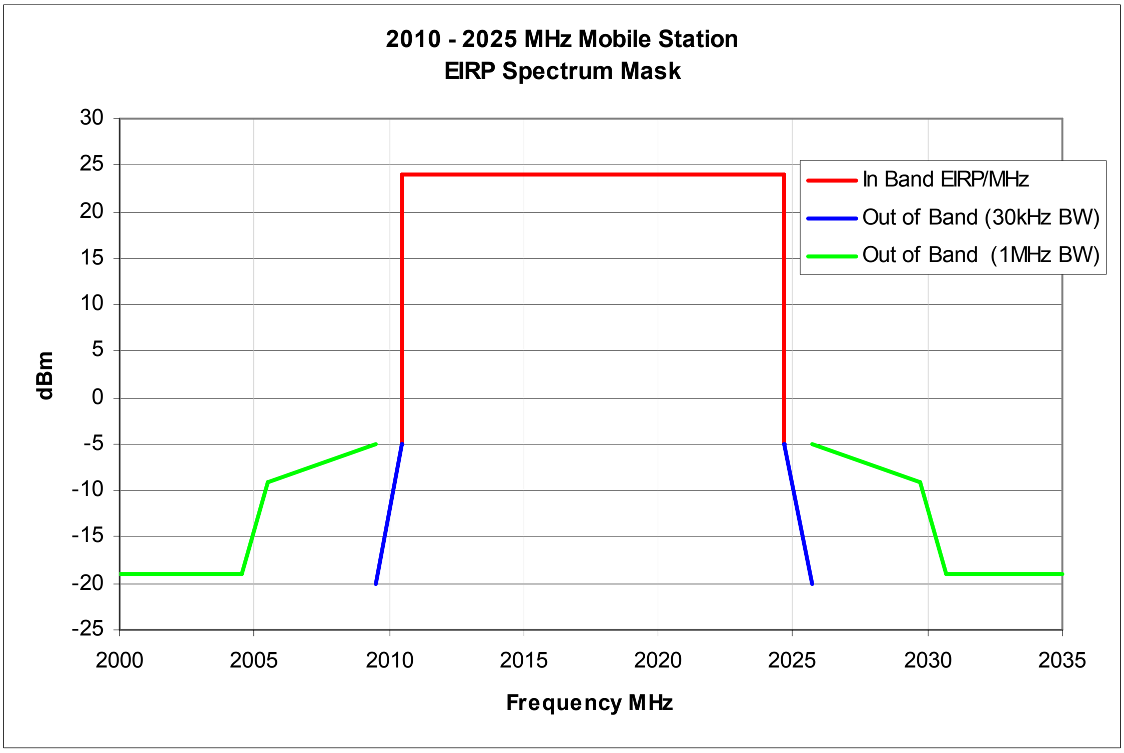
Table 10: 2010 MHz Band – Mobile Station Out-of-band EIRP Mask

Offset from relevant block edge	Maximum mean EIRP
–10.0 to –5.5 MHz (lower edge)	–19 dBm/ MHz
–5.5 to –4.5 MHz (lower edge)	$-9 + 10(\Delta_F + 4.5)$ dBm/ MHz
–4.5 to –0.5 MHz (lower edge)	$-5 + (\Delta_F + 0.5)$ dBm/ MHz
–0.5 to 0.0 MHz (lower edge)	$-12.5 + 15(\Delta_F)$ dBm/30kHz
0.0 to +0.7 MHz (upper edge)	$-9.5 - 15(\Delta_F)$ dBm/30kHz
+0.7 to +4.7 MHz (upper edge)	$-5 - (\Delta_F - 0.7)$ dBm/ MHz
+4.7 to +5.7 MHz (upper edge)	$-9 - 10(\Delta_F - 4.7)$ dBm/ MHz
+5.7 to +10.0 MHz (upper edge)	–19 dBm/ MHz

Where: Δ_F is the frequency offset from the lower block edge (in MHz)
The lower block edge being 2010 MHz
The upper block edge being 2025 MHz

9.31 The above in-band and out-of-band masks are shown in Figure 21 below:

Figure 21: 2010 MHz Band – Mobile Station EIRP Spectrum Mask



2290-2300 MHz

<u>Base stations</u>

9.32 For base stations, the maximum mean EIRP within the 2290 MHz band shall be: 54 dBm/ MHz.

9.33 For bases station out-of-block emissions in the bands immediately adjacent to the 2290 MHz band, the maximum mean EIRP shall not exceed the following mask:

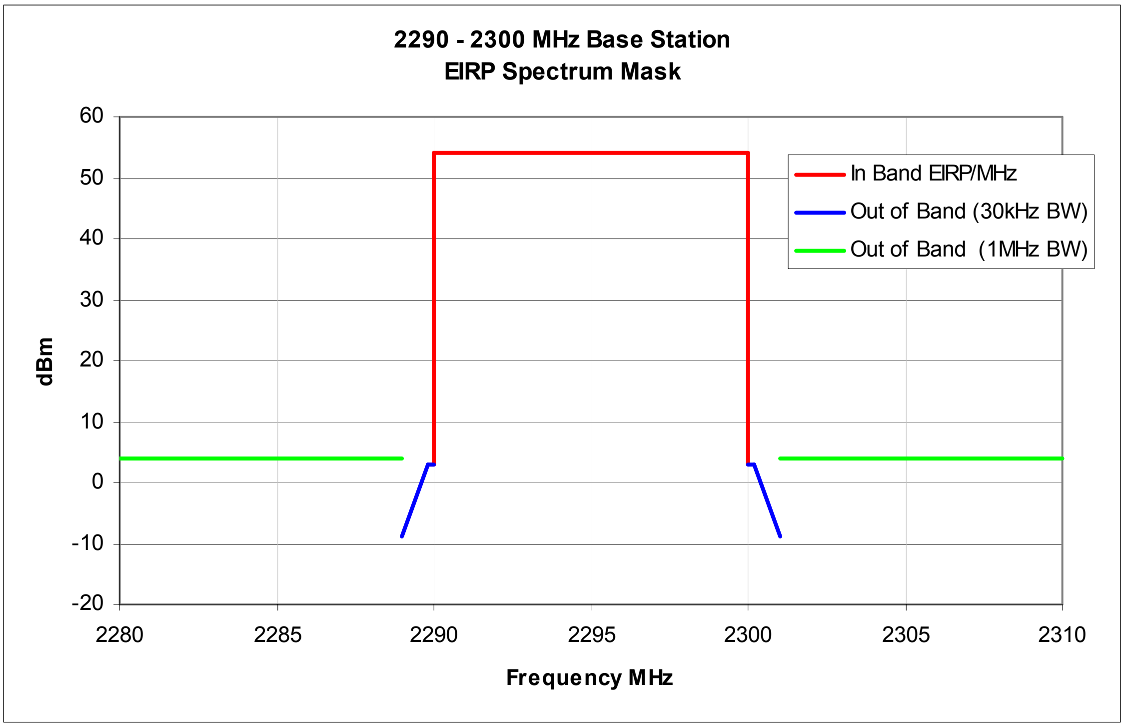
Table 11: 2290 MHz Band – Base Station Out-of-band EIRP Mask

Offset from relevant block edge	Maximum mean EIRP
–10.0 to –1.0 MHz (lower edge)	+4 dBm/ MHz
–1.0 to –0.2 MHz (lower edge)	+3 + 15(Δ_F + 0.2) dBm/30kHz
–0.2 to 0.0 MHz (lower edge)	+3 dBm/30kHz
0.0 to +0.2 MHz (upper edge)	+3 dBm/30kHz
+0.2 to +1.0 MHz (upper edge)	+3 – 15(Δ_F – 0.2) dBm/30kHz
+1.0 to +10.0 MHz (upper edge)	+4 dBm/ MHz

Where: Δ_F is the frequency offset from the lower block edge (in MHz)
The lower block edge being 2290 MHz
The upper block edge being 2300 MHz

9.34 The above in-band power and out-of-band mask is shown in Figure 22 below:

Figure 22: 2290 MHz Band – Base Station EIRP Spectrum Mask



Mobile stations

9.35 For mobile stations, the maximum mean EIRP within the 2290 MHz band shall be: 24 dBm/ MHz.

9.36 For mobile station out-of-block emissions in the bands immediately adjacent to the 2290 MHz band, the maximum mean EIRP shall not exceed the following mask::

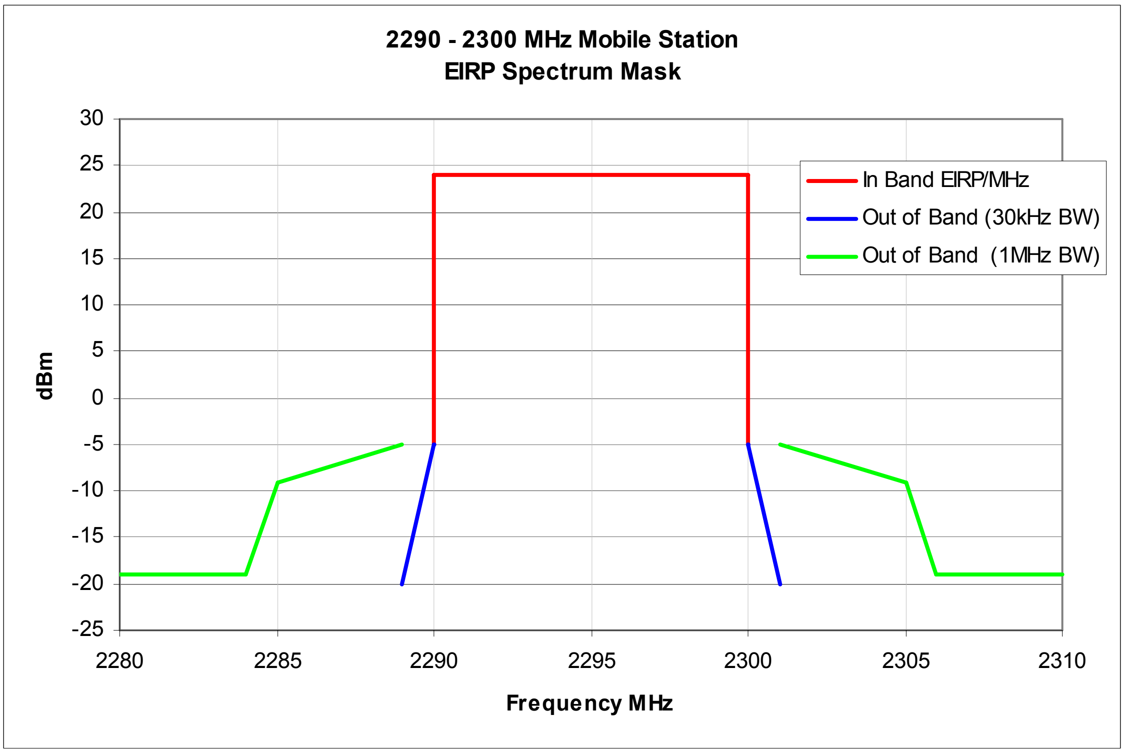
Table 12: 2290 MHz Band – Mobile Station Out-of-band EIRP Mask

Offset from relevant block edge	Maximum mean EIRP
–10.0 to –6.0 MHz (lower edge)	–19 dBm/ MHz
–6.0 to –5.0 MHz (lower edge)	$-9 + 10(\Delta_F + 5.0)$ dBm/ MHz
–5.0 to –1.0 MHz (lower edge)	$-5 + (\Delta_F + 1.0)$ dBm/ MHz
–1.0 to 0.0 MHz (lower edge)	$-5 + 15(\Delta_F)$ dBm/30kHz
0.0 to +1.0 MHz (upper edge)	$-5 - 15(\Delta_F)$ dBm/30kHz
+1.0 to +5.0 MHz (upper edge)	$-5 - (\Delta_F - 1.0)$ dBm/ MHz
+5.0 to +6.0 MHz (upper edge)	$-9 - 10(\Delta_F - 5.0)$ dBm/ MHz
+6.0 to +10.0 MHz (upper edge)	–19 dBm/ MHz

Where: Δ_F is the frequency offset from the lower block edge (in MHz)
The lower block edge being 2290 MHz
The upper block edge being 2300 MHz

9.37 The above in-band power and out-of-band mask is shown in Figure 23 below:

Figure 23: 2290 MHz Band – Mobile Station EIRP Spectrum Mask



Options for the definition of Spectrum Usage Rights

9.38 Ofcom published a consultation document on Spectrum Usage Rights (SURs) on 12 April 2006 and received a range of responses[122]. These were summarised in a note on the way ahead that we published in July 2006. In November 2006, Ofcom published a further note on the way ahead which indicated that Ofcom would focus

[122] http://www.ofcom.org.uk/consult/condocs/sur/

further work on developing specific proposals for SURs in one or more forthcoming spectrum awards and that detailed proposals for the terms of possible SURs would be developed and presented alongside those for the more conventional spectrum mask approach

9.39 It is assumed that stakeholders are familiar with the concept of SURs and the definition of SUR parameters as described in the SUR consultation document. In line with the approach of applying SURs to new licences set out in the SUR consultation document, Ofcom has worked out the SUR parameters for the bands under consideration and is consulting upon these.

9.40 Traditionally licence restrictions have been specified in terms of either technology restrictions, usage restrictions or transmitter emission restrictions. The earlier part of this section described how transmitter emission restrictions could be applied to the bands under consideration.

9.41 As described in the SUR consultation document, transmitter emission restrictions on spectrum use protect neighbouring users against harmful interference indirectly. However licence restrictions defined by SUR parameters directly specify the emissions that a licence holder may radiate in neighbouring locations and frequency bands. This gives licensees more clarity over the interference they can expect and more flexibility in terms of use of their spectrum. In addition, conversely to transmitter emission restrictions, SUR parameters account for the density of deployment of transmitters by a licensee.

9.42 While both transmitter emission restrictions and SUR parameters aim to protect neighbouring (geographical and in terms of frequency) users from harmful interference while providing similar levels of transmitting rights, the specific licensing terms will differ between methods and are not directly comparable.

9.43 The methodology used to derive the SUR parameters is described in Annex 11. It also includes a range of assumptions made in the process.

Definition of SUR parameters

9.44 The SUR consultation document mentions that licensing terms based on SURs consist of the following parameters:

- In-band power flux density (in-band PFD);
- Out-of-band power flux density (out-of-band PFD); and
- Geographical interference based on the aggregate power flux density at a boundary.

9.45 Since national licences rather than regional licences are proposed for the bands under consideration, SUR parameters based on geographical interference have not been set.

9.46 The indicative interference level (IIL) of a channel represents the anticipated interference levels based on the transmit rights of its adjacent neighbours. However, IILs are only indicative because of the probabilistic nature of propagation and the fact that there may be other sources of noise, such as EMC. Although not part of the licence terms, IILs will be provided for the relevant channels. IILs are explained in further detail in Annex 11. It should be noted the IILs are provided for information purposes only and they have no regulatory status. They play a similar roll to Spectrum Quality Benchmarks (SQBs) that have been used elsewhere. IILs quoted in this document are calculated using the best available information that Ofcom has access to at the time. As indicated above IILs have been derived using the methodology described in Annex 11. However, Ofcom cannot guarantee that the assumptions used to generate these IILs will remain valid over time and therefore any perspective users of the 2.6 GHz, 2010 MHz and 2290 MHz bands are advised to treat them with a degree of caution.

9.47 As the detailed application of SURs to these bands has been developed, it has been concluded that slight modifications to the definitions of SUR terms, as set out in the SUR consultation document, would be advantageous. The in-band PFD and out-of-band PFD will now be defined as follows:

- The average in-band PFD at a height H m above ground level should not exceed X_3 dBW/m^2/ MHz at more than Z% of locations in any area A km^2.

- The average out-of-band PFD at a height H m above ground level should not exceed X_2 dBW/m^2/ MHz at more than Z% of locations in any area A km^2.

9.48 It should be noted that the X_3 and X_2 terms above have been used for consistency with the equivalent terms in the SUR consultation (X_1 is not use here as this refers to geographic interference).

9.49 Given that the IIL is based on the out-of-band PFD, it follows that the IIL is defined by

- The IIL at a height H m above ground level should not exceed X_4 dBW/ m^2/ MHz at more than Z% of locations in any area A km^2

9.50 It is assumed that all the SUR parameters should not be exceeded at more than 50% of locations in any area, A. In other words, Z is set to 50%.

9.51 The remaining variables for each SUR parameter will be specified for the relevant channels in the bands under consideration.

Question 19: Do you have any comments on the SUR parameters defined below?

2500-2690 MHz

9.52 For the 2500-2690 MHz band, SUR parameters have been specified for boundary channels and adjacent channels. A boundary channel can be defined as a channel which is either at the band edge or where two disparate services are adjacent to each other (e.g. at the boundary between paired and unpaired use).

9.53 Based on the proposed spectrum packaging options and possible protection offered to users adjacent to the 2500-2690 MHz band, seven cases have been identified for which the SUR parameters will be specified.

9.54 The SURs below are based on the following channel plan. The position of certain blocks will only be known once the outcome of the award is known.

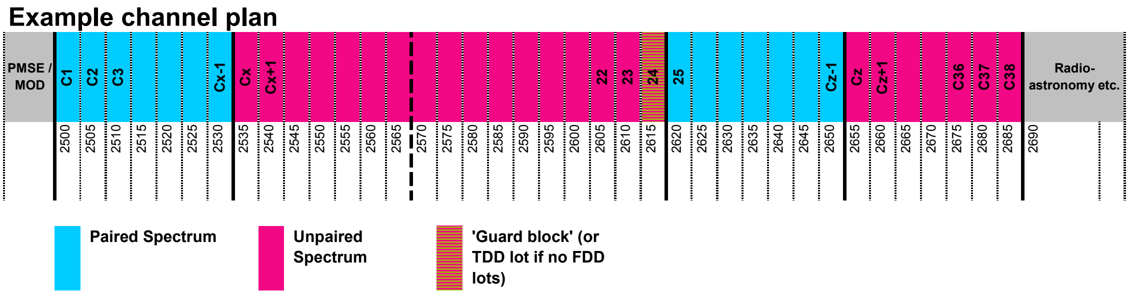


Figure 24: 2.6 GHz band - Channel plan for SUR parameters

<u>Case One: Boundary channel C1 allocated to TDD services</u>

9.55 In Case One (see Figure 25), it is assumed that the TDD channels at the bottom of the 2500-2690 MHz band offer protection to MSS handsets in addition to the protection provided through the ACLR limits specified in the 3GPP standards. The protection relates to the out-of-band emissions of the TDD channels C1 and C2 at 1.5m not exceeding a maximum aggregate out-of-band interference threshold experienced by MSS handsets.

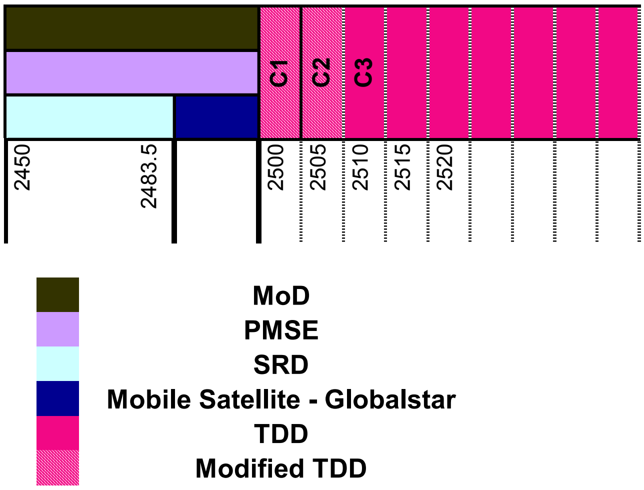


Figure 25: Channels and bands adjacent to the boundary channel C1 which is allocated to TDD services

9.56 Based on this assumption, the in-band and out-of-band PFD of the boundary channel C1 and the channels adjacent to it (i.e. C2 and C3) are provided in Table 13.

Channel	A_1 [km^2]	H [m]	X_3 (*)	X_2 (*)	Δ_F for which X_2 is valid [MHz]
C1	0.14	1.5	-65	-138	-10.0 < Δ_F ≤ 0.0 (lower edge)
				-102	+5.0 > Δ_F ≥ 0.0 (upper edge)
				-112	+10.0 > Δ_F ≥ +5.0 (upper edge)
		10	-64	-101	-5.0 < Δ_F ≤ 0.0 (lower edge) +5.0 > Δ_F ≥ 0.0 (upper edge)
				-111	-10.0 < Δ_F ≤ 5.0 (lower edge) +10.0 > Δ_F ≥ +5.0 (upper edge)
C2	0.14	1.5	-65	-138	-10.0 < Δ_F ≤ 0.0 (lower edge)
				-102	-5.0 < Δ_F ≤ 0.0 (lower edge) +5.0 > Δ_F ≥ 0.0 (upper edge)
				-112	+10.0 > Δ_F ≥ +5.0 (upper edge)
		10	-64	-101	-5.0 < Δ_F ≤ 0.0 (lower edge) +5.0 > Δ_F ≥ 0.0 (upper edge)
				-111	-10.0 < Δ_F ≤ 5.0 (lower edge) +10.0 > Δ_F ≥ +5.0 (upper edge)
C3	0.14	1.5	-65	-102	-5.0 < Δ_F ≤ 0.0 (lower edge) +5.0 > Δ_F ≥ 0.0 (upper edge)
				-112	-10.0 < Δ_F ≤ 5.0 (lower edge) +10.0 > Δ_F ≥ +5.0 (upper edge)
		10	-64	-101	-5.0 < Δ_F ≤ 0.0 (lower edge) +5.0 > Δ_F ≥ 0.0 (upper edge)
				-111	-10.0 < Δ_F ≤ 5.0 (lower edge) +10.0 > Δ_F ≥ +5.0 (upper edge)

Table 13: In-band and out-of-band PFD of channels C1 to C3 assuming TDD services as the most likely use. (*): Units of X2 and X3 are dBW/m2/ MHz. ΔF is the frequency offset from the relevant channel edge

9.57 The in-band and out-of-band PFD at 1.5m and 10m of TDD channels ranging from C4 to C35 are identical to those of channel C3. The in-band and out-of-band PFD of channels C36 to C38 are described in Case Three.

9.58 The IIL of boundary channel C1 and the channels adjacent to it (i.e. C2 and C3) are provided in Table 14.

Channel	A_2 [km^2]	H [m]	X_4 [dBW/m^2/ MHz]
C1	86.67	1.5	-102
		10	-101
C2	0.14	1.5	-99
		10	-98
C3	0.14	1.5	-99
		10	-98

Table 14: IIL of channels C1 to C3 assuming TDD services as the most likely use

9.59 Assuming the out-of-band PFD due to Aeronautical Radionavigation and Radiolocation services are ignored (see Case Three), the IIL of the TDD channels ranging from C4 to C35 is identical to that of channel C3. The IIL of channels C36 to C38 is described in Case Three.

Case Two: Boundary channel C1 allocated to FDD UL services

9.60 In Case Two (see Figure 26), it is assumed that the channels ranging from C1 to Cx-1 are allocated to FDD UL services and that the ACLR limits specified in the 3GPP standards are assumed.

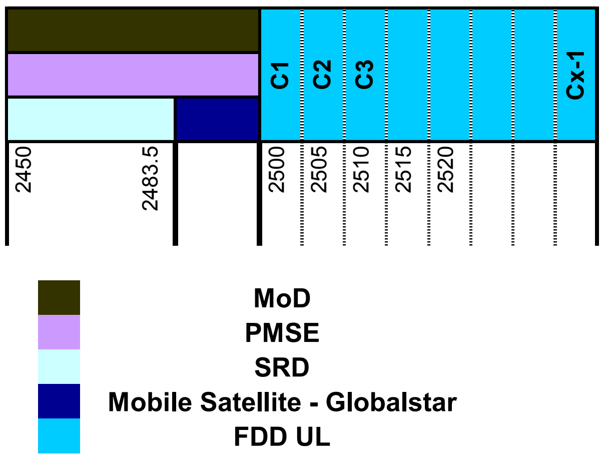


Figure 26: Channels and bands adjacent to the boundary channel C1 which is allocated to FDD UL services

9.61 Based on the above, the in-band and out-of-band PFD of the boundary channel C1 and the channels adjacent to it (i.e. C2 and C3) are provided in Table 15.

Channel	A_1 [km^2]	H [m]	X_3 (*)	X_2 (*)	Δ_F for which X_2 is valid [MHz]
C1	0.34	1.5	-69	-102	$-5.0 < \Delta_F \leq 0.0$ (lower edge) $+5.0 > \Delta_F \geq 0.0$ (upper edge)
				-112	$-10.0 < \Delta_F \leq 5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)
		10	-67	-100	$-5.0 < \Delta_F \leq 0.0$ (lower edge) $+5.0 > \Delta_F \geq 0.0$ (upper edge)
				-110	$-10.0 < \Delta_F \leq 5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)
C2	0.34	1.5	-69	-102	$-5.0 < \Delta_F \leq 0.0$ (lower edge) $+5.0 > \Delta_F \geq 0.0$ (upper edge)
				-112	$-10.0 < \Delta_F \leq 5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)
		10	-67	-100	$-5.0 < \Delta_F \leq 0.0$ (lower edge) $+5.0 > \Delta_F \geq 0.0$ (upper edge)
				-110	$-10.0 < \Delta_F \leq 5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)
C3	0.34	1.5	-69	-102	$-5.0 < \Delta_F \leq 0.0$ (lower edge) $+5.0 > \Delta_F \geq 0.0$ (upper edge)
				-112	$-10.0 < \Delta_F \leq 5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)
		10	-67	-100	$-5.0 < \Delta_F \leq 0.0$ (lower edge) $+5.0 > \Delta_F \geq 0.0$ (upper edge)
				-110	$-10.0 < \Delta_F \leq 5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)

Table 15: In-band and out-of-band PFD of channels C1 to C3 assuming FDD UL services as the most likely use. (*): Units of X2 and X3 are dBW/m2/ MHz. ΔF is the frequency offset from the relevant channel edge

9.62 The in-band and out-of-band PFD of channels C4 to Cx-3 are identical to those of channel C3. The in-band and out-of-band PFD of channels Cx-1 and Cx-2 are described in Case Five.

9.63 The IIL at 10m for channels C1 to C3 is shown in Table 16.

Channel	A_2 [km^2]	H [m]	X_4 [dBW/m^2/ MHz]
C1	86.67	10	-100
C2	0.34	10	-97
C3	0.34	10	-97

Table 16: IIL of channels C1 to C3 assuming FDD UL services as the most likely use

9.64 The IIL of the FDD UL channels ranging from C4 to Cx-3 is identical to that of channel C3. The IIL of channels Cx-1 and Cx-2 is described in Case Five.

Case Three: Boundary channel C38 allocated to TDD services

9.65 In Case Tree (see Figure 27), it is assumed that the channels at the top of the 2500-2690 MHz band are allocated to TDD services. Given that the uses adjacent to the 2690 MHz band edge are not expected to be unduly affected by TDD services operating in the channels at the top of the 2500-2690 MHz band, there are no additional restrictions on the TDD services except for the ACLR limit as specified by the 3GPP standards.

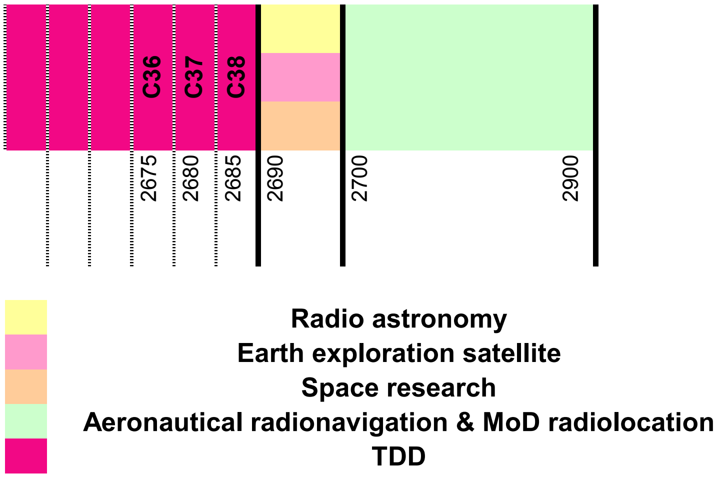


Figure 27: Channels and bands adjacent to the boundary channel C38 which is allocated to TDD services

9.66 Based on the above, the in-band and out-of-band PFD of the boundary channel C38 and the channels adjacent to it (i.e. C36 and C37) are provided in Table 17.

Channel	A_1 [km^2]	H [m]	X_3 (*)	X_2 (*)	Δ_F for which X_2 is valid [MHz]
C36	0.14	1.5	-65	-102	$-5.0 < \Delta_F \leq 0.0$ (lower edge) $+5.0 > \Delta_F \geq 0.0$ (upper edge)
				-112	$-10.0 < \Delta_F \leq 5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)
		10	-64	-101	$-5.0 < \Delta_F \leq 0.0$ (lower edge) $+5.0 > \Delta_F \geq 0.0$ (upper edge)
				-111	$-10.0 < \Delta_F \leq 5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)
C37	0.14	1.5	-65	-102	$-5.0 < \Delta_F \leq 0.0$ (lower edge) $+5.0 > \Delta_F \geq 0.0$ (upper edge)
				-112	$-10.0 < \Delta_F \leq 5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)
		10	-64	-101	$-5.0 < \Delta_F \leq 0.0$ (lower edge) $+5.0 > \Delta_F \geq 0.0$ (upper edge)
				-111	$-10.0 < \Delta_F \leq 5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)
C38	0.14	1.5	-65	-102	$-5.0 < \Delta_F \leq 0.0$ (lower edge) $+5.0 > \Delta_F \geq 0.0$ (upper edge)
				-112	$-10.0 < \Delta_F \leq 5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)
		10	-64	-101	$-5.0 < \Delta_F \leq 0.0$ (lower edge) $+5.0 > \Delta_F \geq 0.0$ (upper edge)
				-111	$-10.0 < \Delta_F \leq 5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)

Table 17: In-band and out-of-band PFD of channels C36 to C38 assuming TDD services as the most likely use. (*): Units of X2 and X3 are dBW/m2/ MHz. ΔF is the frequency offset from the relevant channel edge

9.67 Under the spectrum packaging options, there are two possibilities whereby channels at the top of the 2500-2600 MHz band are allocated to TDD services:

- TDD services are allocated to all the channels in the 2500-2690 MHz band: The in-band and out-of-band PFD for channels ranging from C1 to C35 have been given in Case One.

- TDD services are allocated to channels Cz to C38: The in-band and out-of-band PFD for channels ranging from Cz to C34 are given in Case Seven.

9.68 At the time of writing, out-of-band PFD from the Aeronautical Radionavigation and Radiolocation services were not available but they will be determined prior to any licence award and included in the IIL of channels at the top of the 2500-2690 MHz band. However, assuming the out-of-band PFD from the Aeronautical Radionavigation and Radiolocation services are ignored, the IIL at 1.5m and 10m for channels C36 to C38 is shown in Table 18.

Channel	A_2 [km^2]	H [m]	X_4 [dBW/m^2/ MHz]
C36	0.14	1.5	-99
		10	-98
C37	0.14	1.5	-99
		10	-98
C38	0.14	1.5	-102
		10	-101

Table 18: IIL of channels C36 to C38 assuming TDD services as the most likely use

9.69 Under the spectrum packaging options, there are two possibilities whereby channels at the top of the 2500-2600 MHz band are allocated to TDD services:

- TDD services are allocated to all the channels in the 2500-2690 MHz band: The IIL for channels ranging from C1 to C35 has been given in Case One.
- TDD services are allocated to channels Cz to C38. The IIL for channels ranging from Cz to C34 is given in Case Seven.

Case Four: Boundary channel C38 allocated to FDD DL services

9.70 In Case Four (see Figure 28), it is assumed that the channels ranging from C25 to C38 are allocated to FDD DL services. Given that the uses adjacent to the 2690 MHz band edge are not expected to be unduly affected by FDD DL services operating in the channels at the top of the 2500-2690 MHz band, there are no additional restrictions on the FDD DL services except for the ACLR limit as specified by the 3GPP standards.

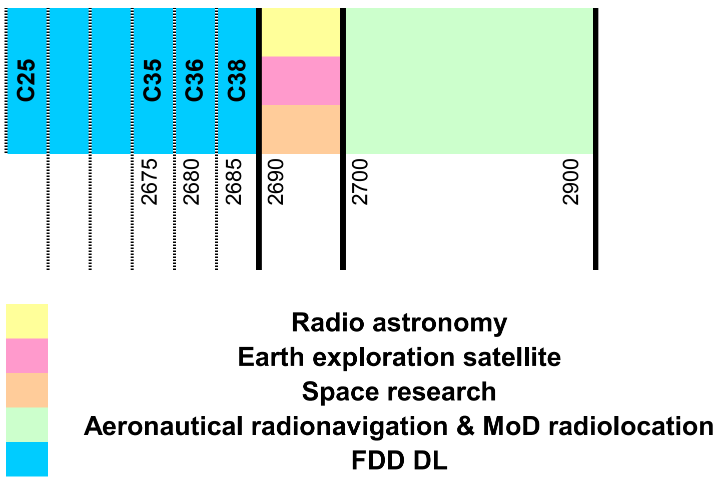


Figure 28: Channels and bands adjacent to the boundary channel C38 which is allocated to FDD DL services

9.71 Based on the above, the in-band and out-of-band PFD of the boundary channel C38 and the channels adjacent to it (i.e. C36 and C37) are provided in Table 19.

Channel	A_1 [km^2]	H [m]	X_3 (*)	X_2 (*)	Δ_F for which X_2 is valid [MHz]
C36	0.34	1.5	-57	-102	$-5.0 < \Delta_F \le 0.0$ (lower edge) $+5.0 > \Delta_F \ge 0.0$ (upper edge)
				-107	$-10.0 < \Delta_F \le 5.0$ (lower edge) $+10.0 > \Delta_F \ge +5.0$ (upper edge)
		10	-54	-99	$-5.0 < \Delta_F \le 0.0$ (lower edge) $+5.0 > \Delta_F \ge 0.0$ (upper edge)
				-104	$-10.0 < \Delta_F \le 5.0$ (lower edge) $+10.0 > \Delta_F \ge +5.0$ (upper edge)
C37	0.34	1.5	-57	-102	$-5.0 < \Delta_F \le 0.0$ (lower edge) $+5.0 > \Delta_F \ge 0.0$ (upper edge)
				-107	$-10.0 < \Delta_F \le 5.0$ (lower edge) $+10.0 > \Delta_F \ge +5.0$ (upper edge)
		10	-54	-99	$-5.0 < \Delta_F \le 0.0$ (lower edge) $+5.0 > \Delta_F \ge 0.0$ (upper edge)
				-104	$-10.0 < \Delta_F \le 5.0$ (lower edge) $+10.0 > \Delta_F \ge +5.0$ (upper edge)
C38	0.34	1.5	-57	-102	$-5.0 < \Delta_F \le 0.0$ (lower edge) $+5.0 > \Delta_F \ge 0.0$ (upper edge)
				-107	$-10.0 < \Delta_F \le 5.0$ (lower edge) $+10.0 > \Delta_F \ge +5.0$ (upper edge)
		10	-54	-99	$-5.0 < \Delta_F \le 0.0$ (lower edge) $+5.0 > \Delta_F \ge 0.0$ (upper edge)
				-104	$-10.0 < \Delta_F \le 5.0$ (lower edge) $+10.0 > \Delta_F \ge +5.0$ (upper edge)

Table 19: In-band and out-of-band PFD of channels C36 to C38 assuming FDD DL services as the most likely use. (*): Units of X2 and X3 are dBW/m2/ MHz. ΔF is the frequency offset from the relevant channel edge

9.72 Assuming the out-of-band PFD from the Aeronautical Radionavigation and Radiolocation services are ignored, the IIL at 1.5m for channels C36 to C38 is shown in Table 20.

Channel	A_2 [km^2]	H [m]	X_4 [dBW/m^2/ MHz]
C36	0.34	1.5	-97
C37	0.34	1.5	-98
C38	0.34	1.5	-100

Table 20: IIL of channels C36 to C38 assuming FDD DL services as the most likely use

9.73 The IIL of the FDD DL channels ranging from C27 to C35 is identical to that of channel C36. The IIL of channels C25 and C26 is given in Case Six.

Case Five: Boundary channel Cx (FDD UL channels adjacent to TDD channels)

9.74 In Case Five (see Figure 29), it is assumed that channels C1 to Cx-1 are allocated to FDD UL services and channels Cx to C24 are allocated to TDD services, such that Cx is the boundary channel between these two services.

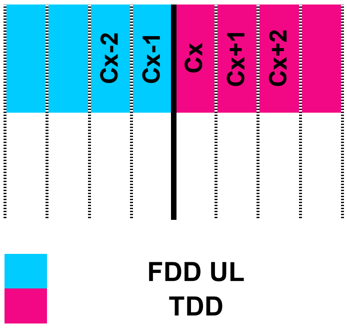


Figure 29: Channels adjacent to the boundary channel Cx which is allocated to TDD services

9.75 The in-band and out-of-band PFD of the boundary channel Cx and the channels adjacent to it (i.e. Cx-1, Cx-2 and Cx+1) are provided in Table 21.

Channel	A_1 [km^2]	H [m]	X_3 (*)	X_2 (*)	Δ_F for which X_2 is valid [MHz]
Cx-2	0.34	1.5	-69	-102	-5.0 < Δ_F ≤ 0.0 (lower edge) +5.0 > Δ_F ≥ 0.0 (upper edge)
				-112	-10.0 < Δ_F ≤ 5.0 (lower edge) +10.0 > Δ_F ≥ +5.0 (upper edge)
		10	-67	-100	-5.0 < Δ_F ≤ 0.0 (lower edge) +5.0 > Δ_F ≥ 0.0 (upper edge)
				-110	-10.0 < Δ_F ≤ 5.0 (lower edge) +10.0 > Δ_F ≥ +5.0 (upper edge)
Cx-1	0.34	1.5	-69	-102	-5.0 < Δ_F ≤ 0.0 (lower edge) +5.0 > Δ_F ≥ 0.0 (upper edge)
				-112	-10.0 < Δ_F ≤ 5.0 (lower edge) +10.0 > Δ_F ≥ +5.0 (upper edge)
		10	-67	-100	-5.0 < Δ_F ≤ 0.0 (lower edge) +5.0 > Δ_F ≥ 0.0 (upper edge)
				-110	-10.0 < Δ_F ≤ 5.0 (lower edge) +10.0 > Δ_F ≥ +5.0 (upper edge)
Cx	0.14	1.5	-65	-102	-5.0 < Δ_F ≤ 0.0 (lower edge) +5.0 > Δ_F ≥ 0.0 (upper edge)
				-112	-10.0 < Δ_F ≤ 5.0 (lower edge) +10.0 > Δ_F ≥ +5.0 (upper edge)
		10	-64	-101	-5.0 < Δ_F ≤ 0.0 (lower edge) +5.0 > Δ_F ≥ 0.0 (upper edge)
				-111	-10.0 < Δ_F ≤ 5.0 (lower edge) +10.0 > Δ_F ≥ +5.0 (upper edge)
Cx+1	0.14	1.5		-102	-5.0 < Δ_F ≤ 0.0 (lower edge) +5.0 > Δ_F ≥ 0.0 (upper edge)
				-112	-10.0 < Δ_F ≤ 5.0 (lower edge) +10.0 > Δ_F ≥ +5.0 (upper edge)
		10		-101	-5.0 < Δ_F ≤ 0.0 (lower edge) +5.0 > Δ_F ≥ 0.0 (upper edge)
				-111	-10.0 < Δ_F ≤ 5.0 (lower edge) +10.0 > Δ_F ≥ +5.0 (upper edge)

Table 21: In-band and out-of-band PFD of channels Cx-2 to Cx+1 assuming channels Cx-1 and Cx-2 are allocated to FDD UL services and channels Cx and Cx+1 are allocated to TDD services. (*): Units of X2 and X3 are dBW/m2/ MHz. ΔF is the frequency offset from the relevant channel edge

9.76 The in-band and out-of-band PFD of the FDD UL channels ranging from C1 to Cx-3 are given in Case Two.

9.77 The in-band and out-of-band PFD of the TDD channels ranging from Cx+2 to C22 is identical to that channel Cx+1. The in-band and out-of-band PFD of TDD channels C23 and C24 are given in Case Six.

9.78 The IIL at 10m for the FDD UL channels Cx-1 and Cx-2 and the IIL at 1.5m and 10m for the TDD channels Cx to Cx+2, are shown in Table 22.

Channel	A_2 [km^2]	H [m]	X_4 [dBW/m^2/ MHz]
Cx-2	0.34	10	-97
Cx-1	0.34	10	-97
Cx	0.34	1.5	-98
		10	-97
Cx+1	0.34	1.5	-99
		10	-98
Cx+2	0.14	1.5	-99
		10	-98

Table 22: IIL of channels Cx-2 to Cx+1 assuming channels Cx-1 and Cx-2 are allocated to FDD UL services and channels Cx and Cx+1 are allocated to TDD services

9.79 The IIL of FDD UL channels ranging from C1 to Cx-3 is given in Case Two. The IIL of the TDD channels ranging from Cx+3 to C22 is identical to that of channel Cx+2. The IIL of channels C23 and C24 is given in Case Six.

Case Six: Boundary channel Cy (TDD channels adjacent to FDD DL channels)

9.80 In Case Six (see Figure 30), it is assumed that channels Cx to C24 are allocated to TDD services and channels C25 to Cz-1 are allocated to FDD DL services, such that C24 is the boundary channel between these two services.

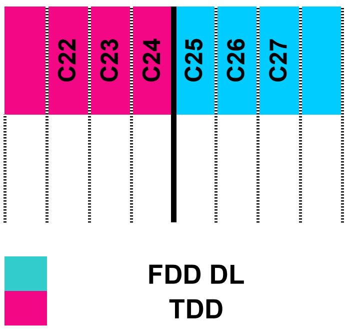


Figure 30: Channels adjacent to the boundary channel C24 which is allocated to TDD services

9.81 The in-band and out-of-band PFD of the boundary channel C24 and the channels adjacent to it (i.e. C23, C25 and C26) are provided in Table 23. Channel C24 is being treated as a normal TDD channel for the purposes of defining SURs though in the award process C24 may in fact be reserved as a guard channel.

Channel	A_1 [km^2]	H [m]	X_3 (*)	X_2 (*)	Δ_F for which X_2 is valid [MHz]
C23	0.14	1.5	-65	-102	$-5.0 < \Delta_F \leq 0.0$ (lower edge) $+5.0 > \Delta_F \geq 0.0$ (upper edge)
				-112	$-10.0 < \Delta_F \leq 5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)
		10	-64	-101	$-5.0 < \Delta_F \leq 0.0$ (lower edge) $+5.0 > \Delta_F \geq 0.0$ (upper edge)
				-111	$-10.0 < \Delta_F \leq 5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)
C24	0.14	1.5	-65	-102	$-5.0 < \Delta_F \leq 0.0$ (lower edge) $+5.0 > \Delta_F \geq 0.0$ (upper edge)
				-112	$-10.0 < \Delta_F \leq 5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)
		10	-64	-101	$-5.0 < \Delta_F \leq 0.0$ (lower edge) $+5.0 > \Delta_F \geq 0.0$ (upper edge)
				-111	$-10.0 < \Delta_F \leq 5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)
C25	0.34	1.5	-57	-102	$-5.0 < \Delta_F \leq 0.0$ (lower edge) $+5.0 > \Delta_F \geq 0.0$ (upper edge)
				-107	$-10.0 < \Delta_F \leq 5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)
		10	-54	-99	$-5.0 < \Delta_F \leq 0.0$ (lower edge) $+5.0 > \Delta_F \geq 0.0$ (upper edge)
				-104	$-10.0 < \Delta_F \leq 5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)
C26	0.34	1.5	-57	-102	$-5.0 < \Delta_F \leq 0.0$ (lower edge) $+5.0 > \Delta_F \geq 0.0$ (upper edge)
				-107	$-10.0 < \Delta_F \leq 5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)
		10	-54	-99	$-5.0 < \Delta_F \leq 0.0$ (lower edge) $+5.0 > \Delta_F \geq 0.0$ (upper edge)
				-104	$-10.0 < \Delta_F \leq 5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)

Table 23: In-band and out-of-band PFD of channels C23 to C26 assuming channels C23 and C24 are allocated to TDD services and channels C25 and C26 are allocated to FDD DL services. (*): Units of X2 and X3 are dBW/m2/ MHz. ΔF is the frequency offset from the relevant channel edge

9.82 Under the spectrum packaging options, FDD DL services may be allocated to:

- Channels C25 to Cz-1: In this scenario, the in-band and out-of-band PFD of the FDD DL channels ranging from C27 to Cz-1 are identical to those of channel C26.

- Channels C25 to C38: In this scenario, the in-band and out-of-band PFD of FDD DL channels ranging from C27 to C38 are given in Case Four.

9.83 The IIL at 1.5m and 10m for the TDD channels C23 and C24 and the IIL at 1.5m for the FDD DL channels C25 and C26, are shown in Table 24.

Channel	A_2 [km^2]	H [m]	X_4 [dBW/m^2/ MHz]
C23	0.34	1.5	-98
		10	-97
C24	0.34	1.5	-98
		10	-96
C25	0.34	1.5	-98
C26	0.34	1.5	-98

Table 24: IIL of channels C23 to C26 assuming channels C23 and C24 are allocated to TDD services and channels C25 and C26 are allocated to FDD DL services

9.84 The IIL of TDD channels ranging from Cx to C22 is given in Case Five.

9.85 Under the spectrum packaging options, FDD DL services may be allocated to:

- Channels C25 to Cz-1: In this scenario, the IIL of FDD DL channels ranging from C27 to Cz-3 is identical to that channel C26. The IIL of FDD DL channels Cz-2 and Cz-1 is identical to that of channels C26 and C25 respectively.

- Channels C25 to C38: In this scenario, the IIL of FDD DL channels ranging from C27 to C38 is given in Case Four.

<u>Case Seven: Boundary channel Cz (FDD DL channels adjacent to TDD channels)</u>

9.86 In Case Seven (see Figure 31), it is assumed that channels C25 to Cz-1 are allocated to FDD DL services and channels Cz to C38 are allocated to TDD services, such that Cz is the boundary channel between these two services.

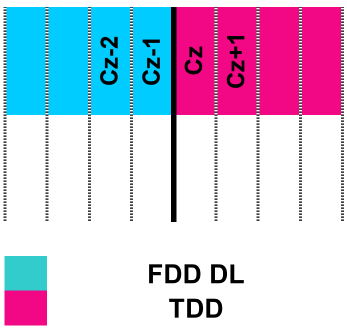


Figure 31: Channels adjacent to the boundary channel Cz which is allocated to TDD services

9.87 Case Seven is identical to Case Six except that the boundary channel, Cz, in Case Seven has the FDD DL channels to its left while the boundary channel, C24, in Case Six has the FDD DL channels to its right.

9.88 Hence the in-band and out-of-band PFD and the ILL of channels Cz-3, Cz-2, Cz-1, Cz, Cz+1, Cz+2 are identical to those of channels C27, C26, C25, C24, C23 and C22 respectively as given in Cases Four to Six where appropriate.

9.89 The in-band and out-of-band PFD and the ILL of channels ranging from Cz+3 to C34 are identical to those of channel Cz+2. The in-band and out-of-band PFD and the ILL of channels C35 to C38 are given in Cases One and Three where appropriate.

2010-2025 MHz

9.90 Ofcom is not proposing to award the 2010-2025 MHz band as multiple 5 MHz lots but rather as a single 15 MHz lot. Hence the 2010-2025 MHz band will be owned by one licensee.

9.91 It is assumed that TDD services are the most likely use of the 2010-2025 MHz band.

9.92 Based on the uses adjacent to the band under consideration, a 500 kHz guard band is required inside the 2010 MHz band edge and a 300 kHz guard band is required inside the 2025 MHz band edge.

9.93 In principle in an SUR framework, there is no need for guard bands as a means of protection to or from adjacent channels. However in this case, Ofcom respects the ECC Decision (06)01 such that the effective band edges are at 2010.5 MHz and 2024.7 MHz.

9.94 Based on the assumptions made in Annex 11, the in-band and out-of-band PFD of the 2010-2025 MHz band are provided in Table 25.

Band	A_1 [km^2]	H [m]	X_3 (*)	X_2 (*)	Δ_F for which X_2 is valid [MHz]
2010.5-2024.7 MHz	0.14	1.5	-65	-99	$-0.5 < \Delta_F \leq 0.0$ (2010.5 MHz boundary) $+0.3 > \Delta_F \geq 0.0$ (2024.7 MHz boundary)
				-102	$-5.0 < \Delta_F \leq -0.5$ (2010.5 MHz boundary) $+5.0 > \Delta_F \geq +0.3$ (2024.7 MHz boundary)
				-109	$-5.5 < \Delta_F \leq -5.0$ (2010.5 MHz boundary) $+5.3 > \Delta_F \geq +5.0$ (2024.7 MHz boundary)
				-112	$-10.0 < \Delta_F \leq -5.5$ (2010.5 MHz boundary) $+10.0 > \Delta_F \geq +5.3$ (2024.7 MHz boundary)
		10	-64	-98	$-0.5 < \Delta_F \leq 0.0$ (2010.5 MHz boundary) $+0.3 > \Delta_F \geq 0.0$ (2024.7 MHz boundary)
				-101	$-5.0 < \Delta_F \leq -0.5$ (2010.5 MHz boundary) $+5.0 > \Delta_F \geq +0.3$ (2024.7 MHz boundary)
				-108	$-5.5 < \Delta_F \leq -5.0$ (2010.5 MHz boundary) $+5.3 > \Delta_F \geq +5.0$ (2024.7 MHz boundary)
				-111	$-10.0 < \Delta_F \leq -5.5$ (2010.5 MHz boundary) $+10.0 > \Delta_F \geq +5.3$ (2024.7 MHz boundary)

Table 25: In-band and out-of-band PFD of the 2010-2025 MHz band assuming TDD services as most likely use and a 500 kHz guard band is required inside the 2010 MHz band edge and a 300 kHz guard band is required inside the 2025 MHz band edge. (*): Units of X2 and X3 are dBW/m2/ MHz. ΔF is the frequency offset from the relevant boundary

9.95 At the time of writing IILs for this band were not available, they will be provided later.

2290-2300 MHz

9.96 Ofcom is not proposing to award the 2290-2300 MHz band as multiple 5 MHz lots but rather as a single 10 MHz lot. Hence the 2290-2300 MHz band will be owned by one licensee.

9.97 There are two most likely uses for the 2290-2300 MHz band, namely TDD and PMSE services.

TDD services as most likely use for the 2290-2300 MHz band

9.98 Based on the assumptions made in Annex 11, the in-band and out-of-band PFD of the 2290-2300 MHz band are provided in Table 26.

Band	A_1 [km^2]	H [m]	X_3 (*)	X_2 (*)	Δ_F for which X_2 is valid [MHz]
2290-2300 MHz	0.14	1.5	-65	-102	$-5.0 < \Delta_F \leq 0.0$ (lower band edge) $+5.0 > \Delta_F \geq 0.0$ (upper band edge)
				-112	$-10.0 < \Delta_F \leq -5.0$ (lower band edge) $+10.0 > \Delta_F \geq +5.0$ (upper band edge)
		10	-64	-101	$-5.0 < \Delta_F \leq 0.0$ (lower band edge) $+5.0 > \Delta_F \geq 0.0$ (upper band edge)
				-111	$-10.0 < \Delta_F \leq -5.0$ (lower band edge) $+10.0 > \Delta_F \geq +5.0$ (upper band edge)

Table 26: In-band and out-of-band PFD of the 2290-2300 MHz band assuming TDD services as most likely use. (*): Units of X2 and X3 are dBW/m2/ MHz. ∆F is the frequency offset from the relevant band edge.

9.99 At the time of writing IILs for this band were not available, they will be provided later.

<u>PMSE services as most likely use for the 2290-2300 MHz band</u>

9.100 Based on the assumptions made in Annex 11, the in-band and out-of-band PFD of the 2290-2300 MHz band are provided in Table 27.

Band	A_1 [km^2]	H [m]	X_3 (*)	X_2 (*)	Δ_F for which X_2 is valid [MHz]
2290-2300 MHz	86.67	1.5	-105	-160	$-1.0 < \Delta_F \leq 0.0$ (lower band edge) $+1.0 > \Delta_F \geq 0.0$ (upper band edge)
				-167	$-2.0 < \Delta_F \leq -1.0$ (lower band edge) $+2.0 > \Delta_F \geq +1.0$ (upper band edge)
				-171	$-3.0 < \Delta_F \leq -2.0$ (lower band edge) $+3.0 > \Delta_F \geq +2.0$ (upper band edge)
				-175	$-4.0 < \Delta_F \leq -3.0$ (lower band edge) $+4.0 > \Delta_F \geq +3.0$ (upper band edge)
				-180	$-5.0 < \Delta_F \leq -4.0$ (lower band edge) $+5.0 > \Delta_F \geq +4.0$ (upper band edge)
		10	-98	-154	$-1.0 < \Delta_F \leq 0.0$ (lower band edge) $+1.0 > \Delta_F \geq 0.0$ (upper band edge)
				-160	$-2.0 < \Delta_F \leq -1.0$ (lower band edge) $+2.0 > \Delta_F \geq +1.0$ (upper band edge)
				-164	$-3.0 < \Delta_F \leq -2.0$ (lower band edge) $+3.0 > \Delta_F \geq +2.0$ (upper band edge)
				-169	$-4.0 < \Delta_F \leq -3.0$ (lower band edge) $+4.0 > \Delta_F \geq +3.0$ (upper band edge)
				-173	$-5.0 < \Delta_F \leq -4.0$ (lower band edge) $+5.0 > \Delta_F \geq +4.0$ (upper band edge)

Table 27: In-band and out-of-band PFD of the 2290-2300 MHz band assuming PMSE services (wireless cameras) as most likely use. (*): Units of X2 and X3 are dBW/m2/MHz. ∆F is the frequency offset from the relevant band edge.

9.101 At the time of writing IILs for this band were not available, they will be provided later.

Other coordination and interference management issues

Interference between the UK and neighbouring countries

9.102 It is anticipated that the UK will enter into cross-border coordination agreements with both France and the Republic of Ireland in respect of the 2010 MHz, 2290 MHz and 2.6 GHz bands. These agreements are likely to be based, at least in part on ECC Recommendation 01-01. It should be noted that this recommendation is currently being updated to cover the 2.6 GHz band. This recommendation is specific to cross-border coordination between UMTS systems but it can provide a benchmark for assessing interference across the border for other predominantly mobile services. However, there are shortcomings to adopting this approach to a technology neutral award. In the 2.6 GHz band for instance, the UK might end up with a situation where base receivers are also present in part of the band where Recommendation 01-01 assumes there should only be mobile receivers and with base transmitters where Recommendation 01-01 assumes there should only be mobile transmitters. In these circumstances, trigger levels specified in Recommendation 01-01 may not be the most appropriate.

9.103 Licensees will be required to observe these and any future agreements negotiated with neighbouring countries, complying with the field strength requirements, including for non-preferred channels, contained in them. Where spectrum users in neighbouring countries are operating within the terms of the cross-border coordination agreements, Ofcom cannot offer any protection to a Licensee operating in border areas (though the chances of interference are considered to be low).

Site clearance

9.104 A valid site clearance certificate issued by Ofcom will be required for certain Radio Equipment radiating more than 17dBW ERP and/or aerial systems, the highest point of which is greater than 30 metres above ground level or where the height of an existing (site cleared) structure has been increased by five metres or more.

9.105 Technical documents and application forms required for site and frequency clearance can be obtained from the Information for Radiocommunications Licensees: Technical Information section of the Ofcom Website[123].

Sitefinder

9.106 Sitefinder is the national database of mobile phone base stations. It was established in response to one of the recommendations of the Group of Independent Experts led by Sir William Stewart which investigated possible hazards posed by mobile phone technologies on behalf of the Government and which reported in May 2000. The Group recommended that reliable and openly available information about the location and operating characteristics of all base stations should be provided by Government. Sitefinder fulfils this recommendation. Ofcom has inherited the responsibility for providing the database on behalf of the Government from the Radiocommunications Agency, which was formerly part of the Department of Trade and Industry.

9.107 The database provides information on all operational GSM, UMTS and TETRA base stations in England, Scotland, Wales and Northern Ireland. Indoor sites in public places such as airports, shopping centres and railway stations are included. The database is provided in the form of an internet website utilising a map driven interface which allows users to see graphically the position of base stations nearest to any location of interest. Brief technical details of each base station can be obtained by clicking on the base station's icon on the map.

9.108 Sitefinder relies on operators voluntarily providing Ofcom with detailed information about each of their sites on a regular basis (currently this is approximately every quarter). The type of information supplied includes:

- the transmit power (dBW); location (in the form of a 10 digit NGR and a postcode);
- height of the antenna above ground level (m);
- the frequency band of operation (e.g. 1800 MHz);
- the technology (i.e. GSM, UMTS, TETRA), etc.

9.109 Ofcom has asked the Government for its views on the relevance of Sitefinder to spectrum awards. The Government has advised that it continues to view Sitefinder as an important resource for consumers.

[123] See http://www.ofcom.org.uk/radiocomms/ifi/tech/ofw191.pdf.

9.110 The Government has also advised that it considers that if the holder of the licence for the Spectrum Bands uses one of the technologies currently covered by Sitefinder, it should be invited to participate voluntarily.

9.111 Consistent with this advice, it is therefore Ofcom's intention to invite the holder of the licence for the Spectrum Bands to participate in providing information about their base stations for inclusion on Sitefinder where they are using one of the technologies currently covered (i.e. GSM, UMTS or TETRA).

9.112 Currently the site information supplied is only made available through the Sitefinder interface. However, the bulk site data used to populate the Sitefinder database has recently been the subject of a ruling by the Information Commissioner. Ofcom considers the bulk data is the property of the operators who supply it. The Information Commissioner has ruled that Ofcom should release the bulk data. Ofcom is currently appealing this ruling.

Section 10

Next steps and timetable

10.1 Subject to consideration of responses to the present consultation, this section sets out the proposed next steps for the award.

Analysis of responses

10.2 Ofcom will analyse all responses it receives by the closing date for this consultation of 9 March 2007 and consider them against its statutory duties in finalising the award process.

Publication of Information Memoranda

10.3 Assuming that Ofcom decides to proceed with awards of the spectrum bands, Ofcom will publish relevant Information Memoranda for the awards, covering separately the award of the 2290 MHz band and the award of the 2.6 GHz and 2010 MHz bands. These will be designed to give bidders as much information as necessary for them to decide whether to enter the auction and how they would prepare for participation. They may be modified or complemented by the publication of updates and answers to specific questions.

Statutory Instruments that allow the awards to take place and define the processes

10.4 In order to give effect to a decision to proceed with awards of the spectrum, Ofcom must make Regulations under its powers contained in the Wireless Telegraphy Act 1998. These Regulations will contain detailed and comprehensive rules and procedures for the running of the auctions. The Regulations are made by means of statutory instruments. They must be published in draft with a minimum of 1 month allowed for comments. After this notice period has expired, Ofcom will make the Regulations and state the date on which they will come into force. This is typically one month after the date the Regulations are made.

10.5 Ofcom expects to publish draft regulations for the awards at the same time as the Information Memoranda. According to Ofcom's provisional timetable, for the award of the 2290 MHz band, publication of the Information Memorandum and of the draft regulations could take place early in the first quarter of 2007/08. In the case of the award of the 2.6 GHz and 2010 MHz band, Ofcom expects to publish those two documents by the summer of 2007. The regulations would then be finalised and made during the summer. As discussed in section 8, it is proposed to hold a separate award for the 2290 MHz band first and then another award for the 2.6 GHz and 2010 MHz bands. Therefore, under current assumptions, the auctions could take place late in the second quarter of 2007/08 for the 2290 MHz band and in the third quarter of 2007/08 for the 2.6 GHz and 2010 MHz bands, subject to on-going European discussions. The reasons for holding the award of the 2290 MHz band first are set out in section 8.

Other regulations and documents for publication

10.6 As part of the preparations for these awards and before prospective bidders are invited to consider participating in the award processes, Ofcom will publish new regulatory documents and amend existing regulations to incorporate the conclusions of this consultation where appropriate.

10.7 This will include:

- amending the spectrum trading regulations (Statutory Instrument 2004 No. 3154) before the award processes to cover the 2.6 GHz, 2010 MHz and 2290 MHz bands;
- publishing interface requirements for the bands before the award process to reflect the technical conditions to be adopted for the licences;
- amending the order limiting the number of licences for certain categories (Statutory Instruments 2003 No. 1902) at the next relevant regular update; and
- amending the UK Frequency Allocation Table at the next relevant regular update and UK Frequency Allocation Plan after the awards to include the new assignments for the bands.

Event and communication on the awards

10.8 Ofcom intends to give one or more presentations during the consultation period to stakeholders interested in these awards to publicise and explain the details.

10.9 This first of these events is likely to take place in early 2007 and parties wishing to attend are welcome to contact Ofcom to express their interest, using the details provided at Annex 1.

10.10 There are likely to be further events to assist potential bidders in understanding the auction rules before the auctions takes place.

Annex 1

Responding to this consultation

How to respond

A1.1 Ofcom invites written views and comments on the issues raised in this document, to be made **by 5pm on 9 March 2007**.

A1.2 Ofcom strongly prefers to receive responses using the online web form at http://www.ofcom.org.uk/consult/condocs/2ghzawards, as this helps us to process the responses quickly and efficiently. We would also be grateful if you could assist us by completing a response (see Annex 3), to indicate whether or not there are confidentiality issues. This response coversheet is incorporated into the online web form questionnaire.

A1.3 For larger consultation responses - particularly those with supporting charts, tables or other data - please email 2GHzawardsconsult@ofcom.org.uk attaching your response in Microsoft Word format, together with a consultation response coversheet.

A1.4 Responses may alternatively be posted or faxed to the address below, marked with the title of the consultation.

Brice Le Cannu
3rd Floor
Spectrum Policy Group
Riverside House
2A Southwark Bridge Road
London SE1 9HA

Fax: 020 7783 43 03

A1.5 Note that we do not need a hard copy in addition to an electronic version. Ofcom will acknowledge receipt of responses if they are submitted using the online web form but not otherwise.

A1.6 It would be helpful if your response could include direct answers to the questions asked in this document, which are listed together at Annex 4. It would also help if you can explain why you hold your views.

Further information

A1.7 If you want to discuss the issues and questions raised in this consultation, or need advice on the appropriate form of response, please contact Brice Le Cannu using the above details.

Confidentiality

A1.8 We believe it is important for everyone interested in an issue to see the views expressed by consultation respondents. We will therefore usually publish all responses on our website, www.ofcom.org.uk, ideally on receipt (when respondents confirm on their response coversheet that this is acceptable).

A1.9 All comments will be treated as non-confidential unless respondents specify that part or all of the response is confidential and should not be disclosed. Please place any confidential parts of a response in a separate annex so that non-confidential parts may be published along with the respondent's identity.

A1.10 Ofcom reserves its power to disclose any information it receives where this is required to facilitate the carrying out of its statutory functions.

A1.11 Please also note that copyright and all other intellectual property in responses will be assumed to be licensed to Ofcom to use in order to meet its legal requirements. Ofcom's approach on intellectual property rights is explained further on its website at http://www.ofcom.org.uk/about/accoun/disclaimer/.

Next steps

A1.12 Following the end of the consultation period, Ofcom expects to publish a statement in the first half of its financial year 2007/08.

A1.13 Please note that you can register to receive free mail Updates alerting you to the publications of relevant Ofcom documents. For more details please see: http://www.ofcom.org.uk/static/subscribe/select_list.htm.

Ofcom's consultation processes

A1.14 Ofcom seeks to ensure that responding to a consultation is easy as possible. For more information please see our consultation principles in Annex 2.

A1.15 If you have any comments or suggestions on how Ofcom conducts its consultations, please call our consultation helpdesk on 020 7981 3003 or e-mail us at consult@ofcom.org.uk. We would particularly welcome thoughts on how Ofcom could more effectively seek the views of those groups or individuals, such as small businesses or particular types of residential consumers, who are less likely to give their opinions through a formal consultation.

A1.16 If you would like to discuss these issues or Ofcom's consultation processes more generally you can alternatively contact Vicki Nash, Director Scotland, who is Ofcom's consultation champion:

Vicki Nash
Ofcom
Sutherland House
149 St. Vincent Street
Glasgow G2 5NW

Tel: 0141 229 7401
Fax: 0141 229 7433

Email vicki.nash@ofcom.org.uk

Annex 2

Ofcom's consultation principles

A2.1 Ofcom has published the following seven principles that it will follow for each public written consultation:

Before the consultation

A2.2 Where possible, we will hold informal talks with people and organisations before announcing a big consultation to find out whether we are thinking in the right direction. If we do not have enough time to do this, we will hold an open meeting to explain our proposals shortly after announcing the consultation.

During the consultation

A2.3 We will be clear about who we are consulting, why, on what questions and for how long.

A2.4 We will make the consultation document as short and simple as possible with a summary of no more than two pages. We will try to make it as easy as possible to give us a written response. If the consultation is complicated, we may provide a shortened version for smaller organisations or individuals who would otherwise not be able to spare the time to share their views.

A2.5 We will normally allow ten weeks for responses to consultations on issues of general interest.

A2.6 There will be a person within Ofcom who will be in charge of making sure we follow our own guidelines and reach out to the largest number of people and organizations interested in the outcome of our decisions. This individual (who we call the consultation champion) will also be the main person to contact with views on the way we run our consultations.

A2.7 If we are not able to follow one of these principles, we will explain why. This may be because a particular issue is urgent. If we need to reduce the amount of time we have set aside for a consultation, we will let those concerned know beforehand that this is a 'red flag consultation' which needs their urgent attention.

After the consultation

A2.8 We will look at each response carefully and with an open mind. We will give reasons for our decisions and will give an account of how the views of those concerned helped shape those decisions.

Annex 3

Consultation response cover sheet

A3.1 In the interests of transparency, we will publish all consultation responses in full on our website, www.ofcom.org.uk, unless a respondent specifies that all or part of their response is confidential. We will also refer to the contents of a response when explaining our decision, without disclosing the specific information that you wish to remain confidential.

A3.2 We have produced a coversheet for responses (see below) and would be very grateful if you could send one with your response (this is incorporated into the online web form if you respond in this way). This will speed up our processing of responses, and help to maintain confidentiality by allowing you to state very clearly what you don't want to be published. We will keep your completed coversheets confidential.

A3.3 The quality of consultation can be enhanced by publishing responses before the consultation period closes. In particular, this can help those individuals and organisations with limited resources or familiarity with the issues to respond in a more informed way. Therefore Ofcom would encourage respondents to complete their coversheet in a way that allows Ofcom to publish their responses upon receipt, rather than waiting until the consultation period has ended.

A3.4 We strongly prefer to receive responses via the online web form which incorporates the coversheet. If you are responding via email, post or fax you can download an electronic copy of this coversheet in Word or RTF format from the 'Consultations' section of our website at www.ofcom.org.uk/consult/.

A3.5 Please put any confidential parts of your response in a separate annex to your response, so that they are clearly identified. This can include information such as your personal background and experience. If you want your name, address, other contact details, or job title to remain confidential, please provide them in your coversheet only so that we don't have to edit your response.

Cover sheet for response to an Ofcom consultation

BASIC DETAILS

Consultation title:

To (Ofcom contact):

Name of respondent:

Representing (self or organisation/s):

Address (if not received by email):

CONFIDENTIALITY

What do you want Ofcom to keep confidential?

Nothing	☐	Name/contact details/job title	☐
Whole response	☐	Organisation	☐
Part of the response	☐	If there is no separate annex, which parts?	

DECLARATION

I confirm that the correspondence supplied with this cover sheet is a formal consultation response. It can be published in full on Ofcom's website, unless otherwise specified on this cover sheet, and I authorise Ofcom to make use of the information in this response to meet its legal requirements. If I have sent my response by email, Ofcom can disregard any standard e-mail text about not disclosing email contents and attachments.

Ofcom seeks to publish responses on receipt. If your response is non-confidential (in whole or in part), and you would prefer us to publish your response only once the consultation has ended, please tick here. ☐

Name

Signed (if hard copy)

Annex 4

Consultation questions

A4.1 This annex provides a list of the questions included in this consultation document.

Question 1: Do you agree with these proposals for the awards of the three bands or have any other comments on the contents of this document?

Question 2: Do you agree with the analysis in section 5 or have any comments on adjacent interference issues?

Question 3: Do you agree that Ofcom should authorise use of the spectrum bands 2500-2690 MHz, 2010-2025 MHz and 2290-2300 MHz?

Question 4: Do you agree that awarding licences by auction would be the appropriate mechanism for authorising use of the spectrum bands 2500-2690 MHz, 2010-2025 MHz and 2290-2300 MHz?

Question 5: Do you agree that it is likely to be in the interests of citizens and consumers to proceed with the award of the 2.6 GHz and 2010 MHz bands as soon as practicable, rather than to delay the award pending reduction in uncertainty relating to other bands?

Question 6: Do you agree Ofcom should aim to award the bands 2500-2690 MHz, 2010-2025 MHz and 2290-2302 MHz by the end of 2007, while keeping the position on the 2.6 GHz and 2010 MHz bands under review in the light of possible developments in European regulatory fora?

Question 7: Do you agree with Ofcom's proposals for licence conditions (technology neutrality, tradability, conditions of tenure and absence of roll-out obligations)?

Question 8: Do you have views on whether or not there should be a "safeguard" cap on the amount of spectrum that any one bidder could win in an award for the 2.6 GHz bands and, if so, do you have a view on whether 90 MHz would be an appropriate size for a safeguard cap?

Question 9: Do you agree with Ofcom's proposal to package spectrum as lots of 2 x 5 MHz for paired use and 5 MHz lots for unpaired spectrum and to allow the aggregation of lots by bidders?

Question 10: Do you agree with Ofcom's proposed approach to allowing the respective amounts of paired to unpaired spectrum for the band 2500-2690 MHz to be varied (maintaining the 120 MHz duplex spacing and allowing additional unpaired spectrum, if needed, at the top end of the band)?

Question 11: Do you agree with Ofcom's proposals for a 5 MHz restricted block between FDD and TDD neighbours and between TDD and TDD neighbours and with a modified out-of-band base station mask for second adjacent 5 MHz blocks?

Question 12: Do you agree with Ofcom's proposals to award the 2010 MHz band as a single 15 MHz lot?

Question 13: Do you agree with Ofcom's proposals to award the 2290 MHz band as a single 10 MHz lot?

Question 14: Do you agree with Ofcom's proposals to combine the award of the 2.6 GHz and 2010 MHz bands and to hold the award of the 2290 MHz band separately and in advance?

Question 15: Do you agree with Ofcom's proposals for a two-stage auction design for the 2.6 GHz and 2010 MHz bands?

Question 16: Do you agree with Ofcom proposals to award the 2290 MHz band through a second price sealed bid auction?

Question 17: Do you have a preference for either of the two approaches to specifying technical licence conditions?

Question 18: Do you have any comments on the transmitter spectrum masks defined below?

Question 19: Do you have any comments on the SUR parameters defined below?

Question 20: Do you have any comments on the SUR methodology and assumptions detailed in this annex?

Question 21: Do you have any comments on the use of the Visualyse tool as described, on the assumptions or the propagation model proposed in this annex?

Question 22: Do you have any comments on the assumptions detailed in this annex?

Annex 5

Impact Assessment

Introduction

A5.1 The analysis presented in this annex represents an impact assessment, as defined in section 7 of the Communications Act 2003 (the Act).

A5.2 You should send any comments on this impact assessment to us by the closing date for this consultation. We will consider all comments before deciding whether to implement our proposals.

A5.3 Impact assessments provide a valuable way of assessing different options for regulation and showing why the preferred option was chosen. They form part of best practice policy-making. This is reflected in section 7 of the Act, which means that generally we have to carry out impact assessments where our proposals would be likely to have a significant effect on businesses or the general public, or when there is a major change in Ofcom's activities. However, as a matter of policy Ofcom is committed to carrying out and publishing impact assessments in relation to the great majority of our policy decisions. For further information about our approach to impact assessments, see the guidelines, Better policy-making: Ofcom's approach to impact assessment, which are on our website: http://www.ofcom.org.uk/consult/policy_making/guidelines.pdf.

The citizen and/or consumer interest

A5.4 The spectrum available has a variety of different potential uses. Ensuring that the spectrum goes to the users which value it the most is usually the best way of seeking to maximise the benefits which go to consumers, in the absence of concerns about market failures, for example the provision of some services may have associated external effects which increase the overall value to society of allocating spectrum to this service. If the intensity of competition in the downstream markets varies, this can also lead to divergences between the value to bidders and the value to consumers.

A5.5 Ofcom believes that overall, its proposal to auction this spectrum on a technology neutral basis is the approach most likely to secure the greatest benefit for consumers. Ofcom's research has shown that awarding this spectrum is likely to increase competition and create considerable benefits for consumer welfare. In addition to these benefits, the spectrum could also enable existing mobile telephony and broadband wireless providers to reduce their costs and much of these savings are likely to be passed onto consumers, given likely levels of competition.

Ofcom's policy objectives

A5.6 Ofcom's objectives are set out in section 6 and relate primarily to ensuring optimal use of the spectrum. For that purpose, it has prepared proposals with a view to provide the relevant degree of flexibility for the market to determine optimal use. Ofcom considers that it should award the available spectrum as soon as practicable, and that the proposed awards could therefore take place by the end of 2007, subject to developments in European regulatory fora.

A5.7 Ofcom considers that regulatory intervention is necessary to define and implement appropriate processes to authorise use of spectrum that is available.

A5.8 Ofcom has considered the following issues and options:

- how the available spectrum should be offered for use – through an auction, "first come, first served" or comparative selection processes;
- when the available spectrum should be offered for use – as soon as practicable or at some later date;
- what the provisions there should be in respect of technologies to be used – technology neutral or technology specific approach;
- packaging the available spectrum to facilitate an efficient award process – relevant sizes and types of lots;
- whether the relevant licensing conditions should include roll-out obligations;
- whether there should be a limit on the amount any one bidder could acquire licences for in the proposed awards;
- what auctions designs are appropriate for the available bands – sealed bid or open multi-round processes and detailed associated processes.

A5.9 Some of these and associated issues are discussed in more detail in section 6 of this consultation document.

Analysis of the different options

A5.10 Ofcom is faced with a number of decisions in awarding this spectrum. This Impact Assessment discusses the approach that Ofcom has considered in developing its proposals concerning each of these decisions. The decisions can be broken down into the following structure.

Choice of assignment mechanism

A5.11 Ofcom could allocate this spectrum in a variety of ways that can be grouped in three ways, auction, "first come, first served" and comparative selection. Comparative selection was ruled out during the SFR:IP consultation process. The other two options are considered below.

A5.12 Auctions are preferable to first come, first served where prior to the award demand for the spectrum exceeds the supply. Only if supply exceeded demand would first come, first served be superior to holding an auction. This is because auctions are most likely to lead to an economically efficient outcome in that they allocate the spectrum to the person who values it the most. Although both bidders and Ofcom will incur transactions costs in participating in and running the auction, previous experience has shown that these costs are very likely to be much less than the value of the spectrum auctioned.

A5.13 Research carried out for Ofcom has shown that shown that many parties are interested in acquiring this spectrum. This combined with our economic modelling has shown that demand for the spectrum is very likely to exceed supply under a wide range of different scenarios concerning end-user demand for services that could be provided using the spectrum and the availability of other spectrum.

A5.14 There may in addition be social benefits attached to the use of the spectrum, which are not typically addressed in auction design, but neither are they addressed by first come, first served. Ofcom believes that where there are social benefits (or costs), these are best addressed by other policy tools that focus directly on the end-user output rather than inputs such as spectrum.

A5.15 Ofcom's preferred approach is to award the spectrum by means of an auction, given that there is clear evidence that demand for the spectrum exceeds its supply. In these conditions an auction is most likely to optimise the value of the spectrum.

Timing of the auctions

A5.16 Ofcom faces two options in deciding when to hold the auction. Either the auction should proceed without delay (potentially during 2007) or the auction should be postponed until a later date when some issues of spectrum availability that are currently uncertain may be clearer.

A5.17 As discussed in more detail in section 6, Ofcom considers that substantial benefits could flow from holding the auction without delay. There is current demand for the spectrum that could generate substantial benefits for society through enabling innovative services and increased competition that will benefit consumers directly.

- There is clear evidence that wireless broadband services service providers would like to use the spectrum to begin offering services right away. Interviews carried out by the Consultants with potential providers of wireless broadband services have substantiated this point.

- Evidence from the United States shows that at least one wireless broadband platform, WiMAX, is in the process of a significant nation-wide role out by established and new service providers. For example, Sprint Nextel has allocated $3 billion for establishing a WiMAX network and services between now and 2008.

- WiMAX and other wireless broadband technologies could bring significant benefits to the UK, and many of these benefits will be passed onto consumers in the form of lower prices from competition and greater choice. If the auction is delayed, at the very least these benefits will be postponed. It is very possible that the loss could exceed this, if there is a limited window of opportunity for WiMAX to establish itself as a competitor for 3G mobile data communications services: i.e. if the auction is delayed, WiMAX operators may find it difficult to enter the market, and the benefits of competition could largely disappear.

- Interviews carried out by the Consultants revealed evidence that MVNOs could be interested in bidding for the spectrum to deploy networks in the near future.

A5.18 Ofcom considers that the potential disadvantages of holding the auction immediately as opposed to postponing until there is greater clarity over the availability of alternative spectrum bands are not strong:

- If at some date in the future there were greater clarity over the availability of spectrum in a number of related bands, in particular 2G liberalisation, it is possible that the auction may arrive at a more efficient outcome given that some participants in the auction would have better information that related to their private values rather than the value that was common to all participants in the auction.

- However, Ofcom does not consider (according to the research Ofcom commissioned) that the degree of uncertainty regarding the likely scenarios for the liberalisation of 2G spectrum is so large that it is likely to affect the willingness to pay of the MNOs significantly enough to change the outcome of the auction. In other words, based on the Consultants' research, it is unlikely that the efficiency of the auction assignment will be reduced by providing further clarity on 2G liberalisation than there is already.

- The spectrum will be tradable, therefore, if the market is working effectively and transaction costs are not high, a more efficient allocation could arise through secondary market transactions.

Technology and service neutrality

A5.19 This spectrum could be awarded on either a technology and service neutral basis or it could be mandated for a particular technology or service. These options are considered in the table below.

Option	Advantages	Disadvantages
Technology and service neutral approach	The potential efficiency of the auction is maximised by allowing bidders the option of using the technology and service that they prefer Demand assessment suggests that a range of different technologies and services wish to use this spectrum, this approach allows the market to choose the best use Consistent with the framework directive Does not constrain future use	Bidders in auction face uncertainty over nature of adjacent users (although risks can be mitigated by defining appropriate spectrum usage rights) A binding European harmonisation decision could be adopted contrary to technology neutrality. However, discussions in European fora strongly suggest that it is unlikely that, were a decision to be adopted, it would be counter to a technology and service neutral approach to licensing this spectrum.
Mandate a specific service or technology	Bidders have certainty over nature of adjacent spectrum users In certain circumstances, may assist in facilitating international harmonisation of equipment (though this can also be achieved by less intrusive means).	Requires Ofcom to choose one or more technologies or services. It could also require Ofcom to mandate how much of the band to allocate to specific technologies or services. There are many potential ways to allocate the spectrum efficiently depending on the underlying market conditions. Ofcom has less information than the market, therefore there is a significant risk that the choice of technology or services is sub-optimal. Could exclude technologies or

		services that may provide greater benefits than the chosen technologies or services

A5.20 Therefore, because the market is more likely to achieve the most efficient outcome, and given that the risk of a restrictive European harmonisation measure is low and no higher than in other similar awards of spectrum Ofcom has considered, Ofcom proposes to use a technology and service neutral approach to award this spectrum.

Packaging options

A5.21 In the 2.6 GHz band, the two main issues are the size of lots which should be auctioned and the planning of the band in terms of the split between paired and unpaired spectrum. In the 2010-2025 MHz band, the issue is the size (and therefore number) of the lots which should be offered. In the 2290-2302 MHz band, there is only one issue, whether to reserve the top 2 MHz for future award and award just 2290-2300 MHz at this time. The alternative options for each issue are discussed in the table below.

Option	Advantages	Disadvantages
2.6 GHz - size and number of lots		
5 MHz lots (paired or unpaired)	5 MHz is the smallest amount of spectrum which all potential uses of the spectrum identified by the Consultants can use. Allows flexibility and is mostly likely to lead to an efficient outcome - research and interviews indicate that some bidders could feasibly require any multiples of 5 MHz lots from 5 to at least 50 MHz. Ofcom does not have to predetermine the optimum package size that bidders may require.	More sophisticated auction formats may be needed to enable bidders to express their demands for combinations of the lots.
10 MHz lots or greater (paired or unpaired)	Larger lots, reducing the number of lots could potentially increase the simplicity of the auction. E.g. in a package auction format, the number of packages that could be bid on would be smaller. Further predetermining the packages to be bid on could eliminate the need for package bidding entirely.	Large lots or predetermined packages will greatly limit bidders' flexibility to bid on the packages they want, and it will be impossible to enable all bidders to express demand for the packages they might want.
2.6 GHz - band plan, division between paired and unpaired lots		
Auction	Efficient outcome - market	Equipment costs may potentially be

decides split, 120 MHz duplex spacing maintained	determines split of spectrum between paired and unpaired uses.	higher, if UK band plan is different from rest of Europe, but current evidence suggest differences are likely to be small. Introduces one extra potential division between paired and unpaired spectrum, requiring restrictions on affected spectrum.
Auction decides split, alternative duplex spacings considered	Efficient outcome - market determines split of spectrum between paired and unpaired uses. No additional division between paired and unpaired spectrum is required if demand for unpaired spectrum > 50 MHz.	Equipment costs may potentially be higher, if UK band plan is different from rest of Europe. It is not certain whether an alternative duplex spacing would add significantly to equipment costs.
CEPT band plan - 2x70 MHz paired, 50 MHz unpaired	Maximum economies of scale can be exploited, presuming that rest of Europe follows CEPT band plan. Minimises risk of interference (and consumer detriment) from non-UK mobile terminals transmitting in parts of the band being used for FDD downlink or TDD in the UK.	Risks inefficiency if the optimum division of spectrum between paired and unpaired is different to the CEPT band plan. Consultancy research shows a range of different outcomes which increases the risk that regulators are unable to determine the optimum allocation of spectrum.
2010-2025 MHz - size and number of lots		
One single 15 MHz lot	Fits the needs of many users well. Allows potential users requiring less than 15 MHz to agree how they could coordinate to use the spectrum, rather than Ofcom setting one-size fits all restrictions on the use of smaller lots.	If there are bidders who only require 5 MHz, they will face transaction costs in trying to acquire the spectrum either by bidding with similar parties in the auction, or acquiring part of the spectrum in the secondary market.
Three lots of 5 MHz	Reduces potential transaction and coordination costs for bidders that only want 5 MHz of spectrum. However, depending on the auction design, such bidders may need to coordinate anyway to overcome threshold risks to collectively displace bidders for several blocks.	The utility of the spectrum would be substantially reduced because Ofcom will have to impose as a default very restrictive usage rights in order to allow separate uses to coexist.
2290-2302 MHz - amount of spectrum to be awarded		
Auction 2290-2300 MHz only vs. all 12	The potential bidders identified in interviews, i.e. PMSE only require 10 MHz; it is unnecessary to	

MHz	auction all 12 MHz. Future transaction costs could be minimised if there is a possibility of combining the spectrum with 2302-2310 to form another 10 MHz package.	

A5.22 Ofcom's conclusions are as follows:

- Ofcom considers that the evidence is strongly in favour of packaging the 2.6 GHz award as 5 MHz lots (paired and unpaired). This allows maximum flexibility for all potential bidders, and the costs of any additional auction complexity are likely to be small compared to the potential gains in efficiency this will bring compared to the alternatives.
- Ofcom's preferred band plan for 2.6 GHz is that the split between paired and unpaired spectrum should be determined in the auction, but that 120 MHz duplex spacing specified in the CEPT band plan should be maintained. Ofcom research suggests that the equipment costs are unlikely to be significantly higher given this departure from the CEPT band plan, and that there are considerable benefits to giving market the flexibility to determine the division of the spectrum between paired and unpaired. Currently this option seems superior to the variant where an alternative duplex spacing would be implemented because it is more likely that equipment costs would not be significantly affected.
- Ofcom considers that it is better to package the 2010-2025 MHz band as one single lot. The alternative of offering three lots of 5 MHz would mean that Ofcom would have to set unduly restrictive rights on this spectrum, severely restricting the services that could be offered.
- Ofcom considers that it is far better to auction only the first 10 MHz of the 2290-2302 MHz band, thus minimising the costs of acquiring the spectrum for any future user who might require 2300-2302 MHz as part of a wider package.

Licensing conditions

A5.23 One of the potential uses of this spectrum is for advanced mobile telephony, in particular for services similar to those that can be provided over existing 3G networks. The licences which have currently been issued for 3G contain a rollout obligation; to cover 80% of the UK population by 2007. This raises the issue of whether a similar obligation should be included in the licences awarded in the 2.6 GHz band in particular. This issue is discussed in the table below.

Option	**Advantages**	**Disadvantages**
Do not include roll-out obligations in 2.6 GHz licences	Licensees are free to rollout their networks in accordance with market demand. Ofcom does not consider that rollout obligations would be likely to benefit consumers. Not including them, therefore avoids imposing	Competition could be distorted, if incumbents are unable to respond to new entrants that target specific customers or areas (because they do not have a roll-out obligation). However, Ofcom considers that this is unlikely to occur because there are a number of ways in which incumbents

	unnecessary additional costs on service providers.	could respond to a geographically focused new entrant, including by changing their tariff structure. For example, if large users were being targeted by new entrants, incumbents could put together pricing packages tailored to this customer segment that enabled them to offer competitive prices, e.g. volume discounts. In addition, at the time of the 3G auction in 2000, the possibility that further spectrum could be released, with potentially different licence conditions, which could be used to enter the markets served by 3G operators was made known and bidders should have taken this into account in the amounts they bid for the spectrum. It is also likely that the 3G rollout obligations will have only affected the speed of roll-out not the ultimate extent, therefore reducing the scale of any cost advantage that entrants may enjoy and reducing further the potential for any distortion of competition. The extra costs should be reflected (among other factors) in the value of existing licences relative to new licences unencumbered by roll-out obligations.
Include roll-out obligations in 2.6 GHz licences	Includes identical provisions in licences of existing 3G operators and potential new operators who could provide 3G services or other services.	Imposes unnecessary restrictions on users of the 2.6 GHz which are unlikely to be economically efficient.

A5.24 Ofcom's conclusion is that it is preferable not to include rollout obligations in the 2.6 GHz licences. The economic benefits appear to be very small and the costs on producers could be large. Though this would imply that new entrants would be treated differently to incumbent 3G MNOs, Ofcom believes that the impact of this on competition in downstream markets will be limited.

Competition issues

A5.25 There are potential measures that Ofcom could take to mitigate in the auction risks to the competitive environment for the provision of services.

Option	Advantages	Disadvantages
Impose no restrictions	Bidders can express their demand for every quantity of spectrum that they require promoting an efficient auction outcome.	It is possible that a bidder could try to acquire the entire spectrum for anti-competitive reasons. In mitigation, the potential cost of buying the entire spectrum, given the large amount available, makes this very unlikely. The potential gains from limiting competition, given there are already five established 3G MNOs in the market, appear small in comparison to the likely cost.
Impose a "strong" spectrum cap e.g. 60 MHz	It is easier to intervene in the primary award of spectrum. Intervening after could take considerable time, particularly because of the need to demonstrate abuse of a dominant position.	Ofcom has to finely judge the maximum amount of spectrum that a bidder could require. This risks setting the level too low, and preventing some users from making the most efficient use of the spectrum available. It is difficult for Ofcom to know better than the market what the maximum level should be.
Impose a "safeguard" spectrum cap e.g. 90 MHz	This guards against a low risk, but high cost scenario where one participant acquires all the spectrum and then refuses to trade it for anti-competitive reasons to more efficient users. Although there are ex post competition powers to address this type of behaviour, this type of action can be lengthy and given the large amount of spectrum available, the potential costs of delay could be high.	There is a risk that some legitimate applications e.g. a band manager might be excluded, however this risk appears very small given the size of the cap in relation to the amounts of spectrum that bidders may want to acquire according to Ofcom's research.

A5.26 Ofcom considers the choice between not introducing spectrum caps and setting a safeguard cap finely balanced. However Ofcom rejects setting a low cap because of the much greater potential for regulatory failure in setting the precise level of the caps.

Auction design options: 2290-2300 MHz (2300-2302 MHz reserved for future award)

A5.27 Ofcom considered the following options for the design of the award of 2290-2302 MHz:

- separate this award from that of 2.6 GHz and 2010-2025 MHz; and

- use a second price sealed bid vs. a simultaneous multi round ascending auction (SMRA).

A5.28 These options are discussed in the table below.

Option	Advantages	Disadvantages
Separate this award rather than link to 2.6 GHz and 2010 MHz	A simpler format can be used for the award of this band compared to the other two. It may be possible to make the spectrum available earlier if it is not linked, since the format will be simpler. The 2.6 GHz award is not complicated by introducing a category of spectrum of low substitutability for most bidders.	In theory there is a substitution risk for PMSE bidders, however in practice this is likely to have little effect if this award is separate from the other bands. PMSE bidders are much more likely to have a good chance of being winners in this band than in the other two.
Use a second price sealed bid rather than an SMRA	For a single lot auction, a second price sealed bid is unlikely to be less efficient than an SMRA provided that bidder asymmetry is not significant and that common value uncertainty is not large. For small bidders, the cost of participating in a sealed bid auction may be significantly lower than in an SMRA, especially in terms of management time.	An SMRA format that allows bidders sufficient time to revise their budgetary limits in the light of other bids may have some benefits over a sealed bid auction in terms of the rationality of bidding. However experimental evidence is inconclusive on this point.

A5.29 Ofcom's preferred options are as follows.

- To separate the award of 2290-2300 MHz from the other bands in view of the low substitution risk for PMSE bidders in practice and the benefits in terms of reducing the complexity of both this auction and potentially the other bands.

- To use a second price sealed bid auction format. Although the alternative might in some circumstances deliver greater gains in terms of auction efficiency, such gains are not considered to be material here and Ofcom considers that the lower participation cost of a sealed bid format could make a significant difference to the likely bidders (PMSE users) for this spectrum, as well as being cheaper for Ofcom to administer.

A5.30 Ofcom has also considered what level of transparency should be provided in this auction, in terms of the identities of the bidders and the amounts bid in the auction. As explained in the main body of this Consultation, Ofcom's preferred options are that:

- the identity of the bidders should be made public; and

- the amounts bid by the losing bidders in the auction should not be made public until the 2.6 GHz auction has concluded. The amount bid by the winning bidder should not be revealed at all.

A5.31 Ofcom's analysis suggested that revealing the identity of the bidders would be unlikely to negatively impact the efficiency of the auction and could increase the amount of information available to bidders, allowing them to more accurately estimate the value of the spectrum to themselves.

A5.32 Ofcom considers that if the amounts bid by losing bidders in this auction were revealed before the conclusion of the combined 2.6 GHz and 2010 MHz auction, participants in the 2290 MHz auction may feel that they would be at a disadvantage if they participated in the second auction because other bidders could infer their values for the spectrum. Therefore Ofcom concluded not to publish this information until the end of the combined 2.6 GHz and 2010 MHz auction.

A5.33 Further Ofcom concluded that the amount bid by the winning bidder should not be made public at all because for the winner, its true valuation could be commercially sensitive. The prospect of this information being revealed could damage bidders' incentives to bid their full value in the second price sealed bid auction format and potentially lead to a less efficient outcome.

Auction design options: 2010-2025 MHz

A5.34 Ofcom considered the option of separating the award of 2010-2025 MHz versus linking it to 2.6 GHz.

A5.35 These options are discussed in the table below.

Option	Advantages	Disadvantages
Link this award to 2.6 GHz rather than separate them	It is clearly likely that this spectrum may be a close substitute for 2.6 GHz, therefore bidders may face serious substitution risks if the awards are separate. It is also possible that for some bidders this spectrum may be a complement to spectrum in the 2.6 GHz band. Providing the auction design can allow bidding on the relevant packages, aggregation risks can be minimised.	If this spectrum turns out to be an inferior substitute to 2.6 GHz spectrum the rationale for linking the award weakens. If this were true, linking the awards could create opportunities for "gaming" the auction, i.e. strategic manipulation.

A5.36 Ofcom's preferred option is to link the award of this spectrum to the 2.6 GHz award. Although the degree of substitutability between the two bands is unclear, there is a good chance that the bands are sufficiently close that separate auctions would leave some bidders facing major substitution risks. The auction format issues for this spectrum are therefore discussed under the assessment for the 2.6 GHz auction.

Auction design options: 2500-2690 MHz

A5.37 Ofcom faced a number of choices in the auction design for this band. Because there are strong common value elements to this auction, only SMRA formats have been considered since information revelation is very important to ensure efficiency of the auction. In addition, there are potential aggregation and substitution risks. This led Ofcom to consider a reduced set of options capable of dealing with these problems, as set out below:

- Combinatorial Clock auction (SMRA with generic lots) with competitive second phase;
- Combinatorial Clock auction (SMRA with generic lots) with administrative assignment in second phase;
- SMRA with pre-determined lots and package bidding.

A5.38 These options are discussed in the table below.

Option	Advantages	Disadvantages
Combinatorial Clock auction with competitive second phase	The clock phase is relatively simple and has little scope for strategic manipulation. Bidders have a small number of categories to bid on and only have to specify how many lots they want at the current price. Facilitates the market determining the split of the spectrum between paired and unpaired uses. Bidders are able to bid on packages, thus aggregation risks are addressed. The second phase allows bidders to express differences in the value of where in the band lots are located. Threshold problems are reduced because at the end of the clock stage, those bidders still in the auction have little incentive not to bid their full value when asked for their best and final offers. This is due to the second price rule used to determine what the winners pay in this stage.	Some bidders may have incentives for strategic reduction of demand in the clock phase. This is most likely where downstream competition is weak, therefore demand reduction may actually be pro-competitive by making more spectrum available to other bidders. If differences between lots are large, the clock phase will not accurately reveal information to address common value uncertainty.
Combinatorial Clock auction with administrative	The clock phase is relatively simple and has little scope for strategic manipulation. Bidders have a small number of categories to bid on and	Some bidders may have incentives for strategic reduction of demand in the clock phase. This is most likely where downstream competition is

assignment in third phase	only have to specify how many lots they want at the current price. Facilitates the market determining the split of the spectrum between paired and unpaired uses. Bidders are able to bid on packages, thus aggregation risks are addressed. If bidders value little where they are located in the band, an administrative second phase is fast and efficient. Threshold problems are reduced because at the end of the clock stage, those bidders still in the auction have little incentive not to bid their full value when asked for their best and final offers. This is due to the second price rule used to determine what the winners pay in this stage.	weak, therefore demand reduction may actually be pro-competitive by making more spectrum available to other bidders. If differences between lots are large, the clock phase will not accurately reveal information to address common value uncertainty. The more lots are imperfect substitutes, the less an administrative assignment is likely to deliver an efficient allocation.
SMRA with pre-determined lots and package bidding	Allows bidders directly to express their preferences on specific lots, therefore addresses aggregation risks.	Determination of winning bids may become complex because of the high number of combinations. A player's bid on any package will depend on the technologies that its neighbour is planning to use. If bidders do not know this the auction outcome may be inefficient. However, if bidders' state their planned technology in advance, the auction would become strategically complex. For example valuations could rise and fall during the auction as the identity of the potential neighbours changes which could cause inefficiencies. Threshold problems may arise where bidders wanting smaller packages find it difficult to coordinate to their mutual benefit and displace larger package bids. The potential to switch bids between lots creates opportunities to manipulate the auction.

A5.39 Ofcom's preferred option is for a Combinatorial Clock auction with a competitive second phase. This option is superior to the SMRA with package bidding because it allows for an efficient solution that deals with the externalities between neighbouring bidders to emerge in the second phase. It involves much less strategic complexity for bidders in taking into account the externalities involving their potential neighbours. Ofcom prefers a competitive over a random assignment in the second stage of the Combinatorial Clock auction because it minimises the risk that the assignment of specific frequencies is inefficient at relatively little extra cost.

Annex 6

Summary of consultation responses relevant to the awards

A6.1 This annex sets out a summary of the responses made to the Spectrum Framework Review: Implementation Plan which are relevant to the spectrum bands discussed in this document as well as an outline of Ofcom's response to the points raised. This annex should be read in conjunction with the rest of the document, where some of these issues are discussed in more detail.

A6.2 The SFR:IP included specific questions on the three available bands.

a) 2.6GHz band

- Is a technology neutral award the right approach for the award of 2500 – 2690 MHz?
- Do you consider an auction in 2006/7 appropriate?
- Do you have any views on the relevance of encouraging new entry through the auction design, and if so how this might be effected?
- What do you consider is the right approach to packaging this spectrum?

b) 2010MHz band

- Is a technology neutral UK licence or licences the right approach?
- Do you think it useful to run the awards for 2010 – 2025 MHz and 2290 – 2302 MHz bands at the same time to facilitate the option of creating potential FDD pairings? How important do you think this is, compared to say the risk of extra complexity?
- Do you have any comments on how the auctions might be linked?

c) 2290MHz band

- Is a technology neutral UK licence or licences the right approach?
- Do you think it useful to run the awards for 2010 – 2025 MHz and 2290 – 2302 MHz bands at the same time to facilitate the option of creating potential FDD pairings? How important do you think this is, compared to say the risk of extra complexity?
- Do you have any comments on how the auctions might be linked?

A6.3 Thirty two respondents provided comments on the proposals for the bands set out in the SFR:IP. Those responses that are not confidential are available on the Ofcom website[124].

A6.4 Some related issues concerning Ofcom's general policy for spectrum awards were also addressed in the SFR:IP Interim Statement (see in particular section 3 and Annex A)[125].

Issue raised	**Comments**	**Ofcom's response**
Technology neutrality for the three bands	BAA, the BBC, Broadband Access Strategies, BT, Channel 4, the Telecommunication Association of the UK Water Industry (TAUWI), Digital TV Group, FMS Solutions, IEEE 802, Intellect, Kingston Communications, Lucent, Nomad Digital, Pipex, Teleware, TCI Ltd, UK Broadband, Vodafone, the Wales Broadband Stakeholder Group and the WiMAX Forum all expressed support for a technology neutral approach or suggested technologies other than IMT-2000 for the 2.6 GHz and 2010 MHz bands. Nortel was in favour of technology neutrality subject to international harmonisation. H3G, the Microwave Group, O2, Siemens Communications, T-Mobile, the UMTS Forum argued that harmonisation for IMT-2000 should be applied to the 2.6 GHz and 2010 MHz bands.	Licence conditions for the available bands are considered in detail in section 6, with the issue of technology neutrality discussed in particular at paragraphs 6.95 to 6.100. Ofcom proposes to award the three available bands on a technology and service neutral basis. This would allow not only IMT-2000 technologies but also other technologies to be used in the available spectrum.

[124] See http://www.ofcom.org.uk/consult/condocs/sfrip/sfip/.
[125] The SFR:IP Interim Statement is available at http://www.ofcom.org.uk/consult/condocs/sfrip/statement/.

Timing of the award of the 2.6GHz band	BT, the CMA, Intellect, Nomad Digital and the WiMAX Forum argued that the 2.6 GHz band should be made available as soon as possible. The Wales Broadband Stakeholder Group commented that an award of the 2.6 GHz band in 2006/07 was appropriate (although it could be delayed slightly). IEEE 802 and Kingston Communications considered that it was appropriate to wait for EU clarity in relation to the 2.6 GHz band and that the award of the band should take place in 2006/07. Orange and Pipex also considered that clarity at EU level was required for an award of the 2.6 GHz band. H3G considered that the 2.6 GHz band should be made available by 1 January 2008, taking account of the provisions of ECC Decision (05)05. Siemens Communications suggested awarding the 2.6 GHz band in 2007/08 to allow the IMT-2000 market to gain momentum. Lucent and some MNOs considered that it was necessary to clarify the policy on liberalisation of mobile (2G) spectrum before awarding the 2.6 GHz band. O2 considered that the award should not take place before 2009/10 at the earliest.	Ofcom has considered the issue of timing of the award in detail in section 6 (see paragraphs 6.22 to 6.89). It proposes to award licences for the three available bands as soon as practicable, subject to developments in European regulatory fora.
Encouraging new entry through the auction design for the 2.6GHz band	BT argued that it may not be clear what a new entrant is. Kingston Communications was of the view that MNOs and others should compete on an equal basis in an auction. The Wales Broadband Stakeholder Group considered that the award process should be as open as possible. O2 considered that measures to encourage entry were not necessary since it viewed mobile markets as competitive. Pipex argued that proactive measures to favour new entrants would be inconsistent with Ofcom's spectrum management policy and that significant market power and anti-competitive	Ofcom agrees that there are circumstances where it may not be simple to determine who would and would not be a new entrant in respect of a spectrum award. This is likely to be particularly true for the award of technology and service neutral licences. Ofcom also notes that it has powers to address issues of significant market power and anti-competitive behaviour in the downstream markets in which service providers using this spectrum are likely to compete (e.g. access and call origination on mobile networks). The risk of regulatory failure is likely to be lower using these powers than by intervening in the award process, particularly given the uncertainty over which markets will be addressed with this spectrum. .

	behaviour can be addressed ex post.	In this consultation, Ofcom is not proposing any specific measures to facilitate the emergence of new entrants per se, other than proposing a fair, transparent and proportionate award process that takes account of all expressions of demand by participants to achieve as efficient an outcome as possible.
Encouraging new entry through the auction design for the 2.6GHz band	Nomad Digital commented that 5 licences should be reserved for bidders offering special benefits (innovation, start-ups, new-entrants, public policy objectives etc) in the 2.6 GHz band and that licence terms should be short, to lower prices in an auction, and encourage new entrants.	Ofcom considers that the measures proposed by Nomad are unlikely to promote efficient use of the spectrum. It is not clear how such criteria as innovation or even new entry could be tested to identify who could meet them. This would result in a high risk of regulatory failure. In respect of the term of the proposed licences, as discussed at paragraphs 6.106 and 6.107, Ofcom considers that an initial term of 20 years is an appropriate term to allow licensees to generate an appropriate return on investment. If the initial licence term were shorter, there would be a risk that some potential users may be deterred from participating in an award and that the outcome would therefore be inefficient.
Encouraging new entry through the auction design for the 2.6GHz band	The Telecommunication Association of the UK Water Industry (TAUWI) suggested that allowing a delayed payment of the auction fee may encourage the participation of innovative new players.	Ofcom considers that such measures as delayed payments of monies in an auction (deposits or auctions fees) might have some positive effects on participation, by providing additional incentives for some to apply for an award. It is not clear however that allowing delayed payments would result in the participation of parties that would otherwise not have taken part. Also, any potential benefits should be weighed against potential disadvantages. There is an increased risk of default associated with such provisions, because bidders are no longer liable for the totality of what they bid in the auction, and therefore could avoid paying the opportunity cost of denying the spectrum to others. This could damage the integrity of an award and substantially reduce its efficiency. Therefore, if Ofcom were to introduce the option of delayed payments, it would probably also need to require specific protections from default from those using that option. It may be that, overall, benefits for bidders of delayed payments are offset by the costs of protection against default.

Encouraging new entry through the auction design for the 2.6GHz band	IEEE 802 argued that new technologies that are spectrally efficient should benefit from advantages in an award to encourage their development.	Ofcom considers that it is for bidders to decide which technologies they want to use and that it would not be appropriate to favour one or several technologies over others. This is discussed at paragraphs 6.95 to 6.100. It is also unclear how the spectral efficiency of technologies would be measured and which technologies would qualify as new technologies. In making such choices, Ofcom would be taking the risk of precluding some potentially efficient outcome from arising. The proposals in this consultation document therefore do not include such provisions.
Encouraging new entry through the auction design for the 2.6GHz band	Siemens argued that beauty contests place a lower financial barrier to entry than auctions. The WiMAX Forum argued that award designs that result in high prices should be avoided to prevent new entrants being priced out.	In section 6, at paragraphs 6.13 to 6.18, Ofcom sets out its view that an auction is the appropriate mechanisms for awarding the 2.6 GHz band in section 6. Ofcom considers that the proposed award design is fair, transparent, proportionate and efficient. Ofcom has also taken into account the impact of the design on incentives to participate in the award and considers that the design is not likely to disadvantage any type of bidder. Auction prices will be determined by demand for the spectrum and bidders' valuations. The proposed auction design has been chosen so as to let the market achieve an efficient allocation of spectrum. If it is efficient for a new entrant to be awarded spectrum, this should happen under the proposed auction design. Ofcom also notes that some beauty contests for spectrum licences include a requirement to make payments for spectrum and that these can either be similar to a single-round auction (if bidders express a willingness to pay at the time of application) or be imposed on licensees (which can affect the efficiency of the award).
Packaging for the 2.6GHz band	BT argued that TDD and FDD blocks should not be packaged together.	Ofcom agrees with this comment and is not proposing that paired (FDD) and unpaired (TDD) blocks be packaged together. Under the proposals set out in sections 7 and 8, bidders can, but do not have to, bid for both paired and unpaired blocks in the 2.6 GHz band. If they wish, bidders can bid for paired lots only or unpaired lots only.

Packaging for the 2.6GHz band	Kingston Communications argued that the frequencies 2570-2620 MHz in the 2.6 GHz band should be reserved for TDD use and treated as part of a specific and separate process. Vodafone was in favour of reducing the amount of TDD spectrum to 30 MHz compared with the CEPT band plan in ECC Decision (05)05 to take account of compatibility with FDD use.	Ofcom considers that it is best to let the market determine the split between paired and unpaired spectrum in the 2.6 GHz band, since it is unlikely that a regulator would be able to determine the split accurately given the uncertainty over demand for the spectrum. Because of the provisions regarding duplex spacing between the two blocks of 5 MHz in a paired lot of 2x5 MHz (fixed at 120 MHz), the minimum amount of unpaired spectrum in the proposed award would be 50 MHz (2570-2620 MHz). Depending on relative demands for paired and unpaired spectrum, the eventual amount of unpaired spectrum could be greater than 50 MHz. However, unpaired spectrum can be used for other types of technologies in addition to TDD, for example unidirectional technologies or FDD technologies by pairing spectrum, which is unpaired within the 2.6GHz band, with an external band.
Packaging for the 2.6GHz band	Vodafone and the WiMAX Forum suggested using blocks of 5 MHz for to package the band.	Ofcom's proposals are based on paired lots of 2x5 MHz and unpaired lots of 5 MHz that participants in the award can aggregate.
Packaging for the 2.6GHz band	Siemens Communications and T-Mobile considered that the 2.6 GHz band should be packaged as per the band plan of ECC Decision (05)05.	For its proposals in section 7, Ofcom has retrained those features of the CEPT band plan that seem appropriate to promote efficient use of the band, i.e. lots based on 5 MHz blocks and duplex spacing of 120 MHz for paired lots. However, Ofcom is not proposing to impose fixed amounts of paired/FDD and unpaired/TDD spectrum.
Packaging for the 2010MHz band	BT and the UMTS Forum considered that the band should be considered as one block of 15 MHz. Siemens Communications made a similar suggestion subject to relevant CEPT work. Kingston Communications and Lucent considered that the 2010 MHz band should be packaged as 5 MHz blocks that bidders could aggregate.	For the reasons discussed in sections 5 and 7 (related to the potential for in-band interference if there were several users), Ofcom proposes to package the 2010 MHz band as one single block of 15 MHz.

Packaging for the 2290MHz band	Intellect and Kingston Communications considered that the packaging of the band should be based on blocks of 5 MHz.	As for the 2010 MHz band, for the reasons discussed in section 5 and 7 (related to the potential for in-band interference if there were several users), Ofcom proposes to package the 2290 MHz band as one single block of 10 MHz.
Potential linkage between the 2010MHz and 2290MHz bands	Some respondents were in favour of allowing linkages between the 2010MHz and 2290 MHz bands.	Having received further evidence on potential uses since preparing the proposals in the SFR:IP, there seems to be little demand for pairing the bands 2010 MHz and 2290 MHz. However, some SFR:IP respondents suggested that the opportunity of pairing the bands should not be precluded. For those reasons, Ofcom is proposing not to link the award of the 2290 MHz and 2010 MHz bands, but has proposed conditions for use of the bands which would not prevent a holder of licences for both bands pairing them (subject to operating within the licence requirements).
Licence exemption for the 2010MHz band	Broadband Access Strategies argued that removing the licence exempt option for the band would impede innovation.	The evidence available to Ofcom shows that no equipment has been developed for licence-exempt use in the band since the identification of this option in 1999. By contrast, there is evidence of demand for licensed use as discussed in sections 2 and 6 of this consultation. Ofcom therefore proposes to make the 2010MHz available for licensed use.
Geographical coverage of licences	BAA indicated a preference for local or regional licences that would be suitable for airports. TAUWI favoured an award that would allow participants to hold regional licences.	Ofcom considers that the potential uses for the available bands are likely to be best supported by the award of national licences. For those uses for which specific geographical locations are relevant, it is highly unlikely that Ofcom could hold sufficient information to identify efficient arrangements as it would run the risk of restricting potentially efficient outcomes for the 2.6GHz, 2010MHz and 2290MHz bands. Under Ofcom's proposals, the scope for access to spectrum in specific geographical areas is provided by spectrum trading, so that the market can develop the efficient solutions.

Participation of smaller companies in the award processes	Broadband Access Strategies and Nomad Digital expressed concerns about the scope for “smaller” companies to be at a disadvantage in participating in the regulatory processes for the award, in preparatory stages for example when small companies follow developments in several national jurisdictions, and during the awards when the process is an auction.	Ofcom welcomes the participation of all stakeholders in the processes leading up to the award of spectrum. It considers that it takes relevant steps to engage with stakeholders as necessary and welcomes suggestions on possible improvements. Ofcom also notes that processes in other jurisdictions are a matter for relevant authorities in those jurisdictions.
‘Use it or lose it’ conditions in spectrum licences	Nomad Digital, TCI Ltd and the Wales Broadband Stakeholder Group argued that ‘use it or lose it’ conditions should be included in the licences for the available bands.	As discussed in section 6 and in the SFR:IP Interim Statement, Ofcom considers that 'use it or lose it’ conditions are not an appropriate tool for ensuring optimal use of the spectrum. Therefore Ofcom is not proposing to include any such conditions in the licences for the 2.6 GHz, 2010 MHz and 2290 MHz bands.
Term of the licences	BT expressed its preference for licences with indefinite terms. Nomad Digital was in favour a 3-year licences with ‘use it or lose it’ conditions for the 2.6 GHz band.	The licence conditions proposed in this consultation include an indefinite term with an initial term of 20 years and additional powers for Ofcom to revoke licences beyond their initial term, as discussed at paragraphs 6.106 and 6.107.
Mast sharing	The Communication Management Association (CMA) argued that Ofcom should consider the case for introducing guidelines in relation to the sharing of masts by wireless operators for the siting of their network equipment and other measures providing scope for cost reductions.	Ofcom is aware of Government initiatives to encourage the sharing of sites and masts for the purpose of installing wireless communications equipment. An example of such initiatives is the Code of Best Practice on Mobile Phone Network Development of November 2002 (see http://www.communities.gov.uk/index.asp?id=1144926). Ofcom welcomes these existing measures and considers that interested parties should take due consideration of these policies.

Technical restrictions on blocks between FDD and TDD use	IEEE 802 considered that restricted blocks or guard bands between TDD and FDD spectrum should be shared equally between the two types of uses.	Under Ofcom's proposals to allow flexibility in the split between paired and unpaired spectrum in the 2.6GHz band, this issue becomes irrelevant. There has to be a guard band / restricted block between TDD and FDD use. But if demand for TDD exceeds 40MHz of usable spectrum, with guard bands of 5MHz on either side, then the boundary between TDD and FDD can adjust through the auction process to accommodate additional TDD use, provided, of course, that the TDD users bid higher than the FDD users they would displace. The details of the proposed approach are set out in section 7 on the packaging of the available spectrum and section 8 on auction format.
Award mechanism – use of auctions	Intellect considered that auctions should only be used where scarcity of spectrum has been demonstrated.	Ofcom considers that in the case of the three available bands, it is highly likely that demand will exceed supply. This is discussed further at paragraphs 6.30 to 6.39. In addition, the processes proposed by Ofcom should enable to assess whether there is excess demand before starting the bidding process (e.g. if the combined eligibility of all bidders exceeds the available spectrum at 2.6GHz and 2010MHz or if there are more than one bidder for the 2290MHz band). If there is no excess demand, then there would not be a need to proceed to a competitive bidding stage under the proposed processes and the awards would in be 'first-come first-served' processes with a licence fee equal to the reserve price.
Restrictions on mobile use in new spectrum licences – differences in licence conditions with 3G licences & 2G licences	O2, T- Mobile and Vodafone commented that to award new spectrum licences without roll-out obligations would be discriminatory and distort competition. T-Mobile also argued that the costs of meeting the obligations would take some time to recover and this would not be achieved before 2012. T-Mobile also commented that to award new spectrum licences which allowed the holders to obtain spectrum at significantly less cost than 3G licensees was discriminatory and would distort competition. O2 and T-Mobile also commented that to award new spectrum licences with an indefinite term compared with the fixed term of 3G licences would be discriminatory and have adverse impacts on competition.	In section 6 of this consultation document (see paragraphs 6.113 to 6.140) Ofcom considers in detail these points and is of the view that the proposed licence conditions for use of the 2.6 GHz, 2010 MHz and 2290 MHz bands do not give rise to undue discrimination against the MNOs or any other licensees. It is also of the view that to award licences for the use of new spectrum under the proposed licence conditions would be pro-competitive and would not have adverse impacts on competition.

	O2 and Vodafone argued that discrimination would exist vis-à-vis 2G licensees due to the following differences: the ability to trade; the ability to change use; and greater security of tenure. T-Mobile made similar points and focused in particular on the impact of having liberalised rights for the new spectrum.	
Restrictions on mobile use in new spectrum licences so as to prevent / delay new entry and so protect investment by 3G licensees / recovery of costs	H3G commented that restrictions on mobile use should be included in new licences to avoid distorting investment incentives for existing 3G licensees. Vodafone made a similar comment that there was a significant risk that putting large swathes of 3G spectrum onto the market would have a disruptive effect in an immature but growing market, and, further, this might have a long term impact if it prevented market reaching critical mass. T-Mobile similarly argued that restrictions on mobile use should be maintained to avoid or reduce the scope for new entry to adversely affect the business case of itself and other existing 3G licensees.	Ofcom does not accept the arguments raised by the MNOs. It considers that awarding the available bands is likely to have a positive effect on competition and that delaying the awards would result in lost benefits to consumers. This is discussed in more detail in section 6 at paragraphs 6.44 to 6.140.
Restrictions on mobile use in new spectrum licences – change to 3G auction position	Orange commented that restrictions needed to be maintained for a transitional period (not specified) as business cases of existing 3G licences were based on regulatory environment described in the 3G auction and consequent number of competitors which is now being undermined by Ofcom. T-Mobile raised similar concerns suggesting that the statements at the time of 3G auction gave a legitimate expectation that market conditions applicable at the time would remain stable. Vodafone made similar comments on the need to take full account of the implications of previous regulatory decisions in the 3G auction. H3G also commented that it was premature to be changing the regulatory framework established at the time of the 3G auction. It does not believe there are potential benefits which could be achieved that would outweigh the costs.	Ofcom does not accept that there may be legitimate expectations arising from the 3G auction of 2000 that could contradict the proposals set out in this consultation document. It also considers that the balance of advantages and disadvantages is in favour of proceeding with the proposed awards as soon as practicable (subject to developments in European regulatory fora). This is discussed in more detail in section 6.

Restrictions on mobile use in new spectrum licences - lack of market analysis	Orange commented that Ofcom had not set out its market analysis justifying its view that to include restrictions would lead to a loss of competitive stimulus.	Since publication of the SFR:IP, Ofcom has set out its view on the case for technology neutrality in the 2.6 GHz band in its response to the European Commission's invitation for comments on this issue of June 2005. Ofcom's approach for the 2.6 GHz band and the two associated bands is also set out in section 6 of this document (see the discussion on technology neutrality at paragraphs 6.95 to 6.100). Ofcom's view is that it should not include restrictions on the use of technologies or services in the available bands and that this is likely to maximise the benefits of the awards for citizens and consumers.
Award of further spectrum which can be used for 3G is unnecessary	All the MNOs commented to varying degrees that there was no scarcity of spectrum for 3G at present nor was there likely to be on timescales indicated by Ofcom for the award of more spectrum. They claimed, therefore, that it would be inefficient to award more spectrum on the timescales proposed in the SFR:IP.	Ofcom has received evidence of significant demand for the available spectrum bands. On this basis it considers it appropriate that the spectrum is awarded as soon as is feasible, possibly in late 2007. Ofcom also considers that an award on this timetable is likely to result in efficient use of the spectrum. These issues are discussed in more detail in section 2 and section 6.
Linkage with 2G liberalisation	All 2G MNOs commented that, on the basis of previous statements on the management of spectrum, a clear statement on future liberalisation of both current 2G and 3G licences should be a pre-condition to future 3G auctions (which they defined to include the award discussed in this document). O2 also made a similar comment that the failure to address issues relating to 2G refarming and the availability of all substitutable IMT-2000 spectrum before awarding new spectrum would be contrary to administrative practice as set out in HM Treasury's Green book and lead to inefficient assignments.	In section 6, at paragraphs 6.49 to 6.78, Ofcom discusses the information that is already available on the issue of liberalisation of 2G and 3G mobile spectrum and indicates that it also expects to publish further information on the issue in the first half of 2007. Ofcom's view is that any benefit of delay of the award of the 2.6 GHz and 2010 MHz bands would be outweighed by the costs associated with such a delay and that proceeding with the award as soon as practicable as proposed would not adversely impact the scope for an efficient outcome.

Annex 7

List of potential technologies for use in the bands

A7.1 The table below lists technologies that have so far been identified as potential uses of the 2.6 GHz, 2010 MHz and 2290 MHz bands, grouped according to three broad categories, advanced mobile telephony, wireless broadband, mobile multimedia and programme making and special events.

A7.2 The summary of the properties of the technologies shows the relevance of packages based on 5 MHz blocks, paired or unpaired, where interference conditions allow.

A7.3 For the purpose of the technical modelling described in the consultation document, representative technologies were chosen as the basis for representing the forms of emissions that are likely to appear in the available bands. Those technologies are UMTS for the mobile telephony category, WiMAX for wireless broadband and mobile multimedia and a selection for PMSE.

Type of Use	Technology	Standard	Mode of operation (TDD or FDD)	Channel raster	Duplex spacing between downlink and uplink for FDD	Minimum spectrum requirement	Preferred Band(s)
Mobile telephony	UMTS/WCDMA FDD	3GPP UTRAN Release 99; HSDPA – Release 5; HSUPA – Release 6	FDD	5 MHz carrier spacing	120 MHz planned for 2.6 GHz (duplex spacing for the 3G spectrum at 1920-1980 MHz/2110-2170 MHz is 190 MHz)	2 x 5 MHz	1920-1980 MHz/2110-2170 MHz, 2500-2570 MHz/2620-2690 MHz and existing GSM bands (900 MHz and 1800 MHz)
Mobile telephony	UMTS/TD-CDMA TDD	3GPP UTRAN Release 99	TDD	5 MHz carrier spacing	N/A	5 MHz per carrier	1900-1920 MHz, 2010-2025 MHz and 2570-2620 MHz
Mobile telephony	MB (Mobile Broadband) FDD/Wideband OFDM FDD	Adopted January 2006 as technical specification for FDD mode of IEEE802.20 specification	FDD	5 MHz	Various; compatible with existing licensed allocations below 3.5 GHz	2 x 5 MHz	Paired allocations in 1.8 GHz, 1.9 GHz and 2.6 GHz bands
Mobile telephony	MB TDD/Wideband OFDM and SDMA	Adopted January 2006 as technical specification for TDD mode(s) of IEEE802.20 specification	TDD	(1) MB TDD “625kHz mode” – 625 kHz channel spacing (4 x 625kHz in a 2.5 MHz block) (2) MB TDD “Wideband mode” – 5 MHz	N/A	625 kHz/5 MHz	Unpaired allocations in 1.8 GHz, 1.9 GHz and 2.6 GHz bands
Mobile telephony	IBurst/HC-SDMA (High Capacity Spatial Division Multiple Access)	ANSI (USA)	TDD	HC-SDMA uses a 625 kHz carrier bandwidth	N/A	2.5 MHz or 5 MHz (i.e. 4 or 8 x 625 kHz carriers in a block)	Unpaired spectrum in 1.8 GHz, 1.9 GHz and 2.3 GHz bands. Up-banding to 2.6 GHz is planned
Mobile telephony	Flexband/FLASH (Fast Low Latency Access with Seamless Handoff) OFDM	Flarion/Qualcomm proprietary	FDD	1.25 MHz and 5 MHz	Compatible with existing licensed allocations below 3.5 GHz	2 x 1.25 MHz/2 x 5 MHz	Existing mobile telephony spectrum from 450 MHz to 3 GHz

Type of Use	Technology	Standard	Mode of operation (TDD or FDD)	Channel raster	Duplex spacing between downlink and uplink for FDD	Minimum spectrum requirement	Preferred Band(s)
Mobile telephony	CDMA 2000 1X and 1xEV-DO	3GPP2/TIA (USA)	FDD	1.25 MHz and 5 MHz (CDMA 2000 Revision B standard plans aggregated 5 MHz carrier)	80 MHz (for PCS19000 allocations)	2 x 1.25 MHz (for 1X) 2 x 3.75 MHz (for future 3X)	Mobile telephony and PCS spectrum (450 MHz, 800 MHz, 1700 MHz, 1900 MHz, 2100 MHz)
Broadband wireless	WiMAX Revision D	IEEE802.16-d	TDD	5 MHz/10 MHz	N/A	10 MHz minimum, 3 x 10 MHz (30 MHz) preferred	2.3 GHz, 3.5 GHz
Broadband wireless	WiMAX Revision E	IEEE802.16-e	TDD	5 MHz/10 MHz	N/A	10 MHz minimum, 3 x 10 MHz (30 MHz) preferred	2.3 GHz, 2.6 GHz
Broadband wireless	WiBRO	TTA Korea (standard also incorporated in to IEEE802.16/WiMAX Forum)	TDD	8 MHz (10 MHz)	N/A	10 MHz	2.3-2.4 GHz
Mobile Multimedia	DMB	ETSI T-DAB/T-DMB	Broadcast/Unidirectional	1.536 MHz	N/A	One carrier in 1.536 MHz	VHF Band III and L-Band
Mobile Multimedia	DVB-H	ETSI DVB	Broadcast/Unidirectional	4.75 MHz (5 MHz carrier) or 7.61 MHz (8 MHz carrier)	N/A	One carrier in 5 MHz or 8 MHz	VHF Band III, UHF Bands IV and V, L-Band
Mobile Multimedia	MBMS	3GPP UTRAN Release 6	Occupies standard WCDMA paired spectrum, 5 MHz per carrier	5 MHz	Duplex spacing as per WCDMA paired spectrum	2 x 5 MHz	As per WCDMA
Mobile Multimedia	TDtv	3GPP UTRAN Release 6	Occupies standard TD-CDMA unpaired channel, 5 MHz per carrier	5 MHz	N/A	5 MHz	1900-1980 MHz, 2010-2025 MHz, 2110-2170 MHz, 2500-2690 MHz

Type of Use	Technology	Standard	Mode of operation (TDD or FDD)	Channel raster	Duplex spacing between downlink and uplink for FDD	Minimum spectrum requirement	Preferred Band(s)
Mobile Multimedia	3GPP LTE	3GPP Release 8	FDD and TDD	10 MHz-20 MHz	As per standard 3GPP duplex spacing	2 x 10 MHz	2500-2690 MHz and existing bands incorporated in 3GPP standards (1900-1980 MHz, 2110-2170 MHz and existing GSM/Mobile telephony spectrum)
Mobile Multimedia	MediaFLO	Qualcomm	Broadcast/Unidirectional	6 MHz	N/A	6 MHz	450 MHz to 2 GHz (700 MHz initial rollout)
PMSE	Wireless camera	Analogue FM/Digital DVB-T	Unidirectional	20 MHz (analogue) 10 MHz (digital)	N/A	10 MHz (digital), 20 MHz (analogue)	2025-2110 MHz and 2200-2290 MHz (digital only) 2390-2450 MHz, 2500-2690 MHz, 3400-3600 MHz, 5472-5925 MHz, 7110-7424 MHz, 8470-8490 MHz, 1031-1035 MHz and 12.21-12.48 GHz 11.74-11.97 GHz for low power radio cameras
PMSE	Analogue video links	Analogue FM	Unidirectional	20 MHz	N/A	20 MHz	2390-2450 MHz, 2500-2690 MHz, 3400-3600 MHz, 5472-5925 MHz, 7110-7424 MHz, 8470-8490 MHz, 1031-1035 MHz and 12.21-12.48 GHz

Type of Use	Technology	Standard	Mode of operation (TDD or FDD)	Channel raster	Duplex spacing between downlink and uplink for FDD	Minimum spectrum requirement	Preferred Band(s)
PMSE	Digital video links	ETSI DVB-T	Unidirectional	10 MHz	N/A	10 MHz	2025-2110 MHz, 2200-2290 MHz, 2390-2450 MHz, 2500-2690 MHz, 3400-3600 MHz, 5472-5925 MHz, 7110-7424 MHz, 8470-8490 MHz, 1031-1035 MHz and 12.21-12.48 GHz

Annex 8

Auction formats and rules

A8.1 This annex presents the detailed auction rules for the spectrum bands in this award. Ofcom is proposing that the band 2290-2300 MHz should be awarded in a separate auction and that the bands 2010-2025 and 2500-2690 MHz should be awarded in a combined auction. The auction rules for 2290-2300 MHz are set out first followed by those for the combined auction of 2010-2025 and 2500-2690 MHz.

Rules for auction of 2290-2300 MHz

Introduction

A8.2 As explained in section 8, Ofcom identified two main candidate auction formats:

- a single round, sealed bid, second price auction; or
- a simple ascending bid auction.

A8.3 Although both formats should deliver a reasonably efficient auction outcome, Ofcom proposes, on balance, to use a sealed bid format (with a second price rule), as it may impose significantly lower costs particularly for small bidders, it is faster, more cost effective and may be more robust to potential low demand and collusion concerns.

Available spectrum

A8.4 The available spectrum is 12 MHz, located at 2290-2302 MHz. However, as explained in sections 2 and 7 the base unit of demand from all likely bidders is 10 MHz, therefore it appears sensible to package the spectrum as a single lot of 10 MHz in the range 2290-2300 MHz.

A8.5 As discussed in section 8, Ofcom considers that any linkages between the 2290-2302 MHz band and the bands 2010-2025 MHz and 2.6 GHz in terms of spectrum being strongly complementary or substitutable would not be sufficient to warrant a combined process involving all three bands. As a result Ofcom is proposing not to link the auction of 2290-2300 MHz with the other bands and to award it as part of a distinct process. However, these proposals include specific provisions on transparency in respect of those linkages that may exist, as discussed below.

Proposed auction format

A8.6 The auction format proposed is a single round, sealed bid. Bidders are invited to submit a single bid for the 10 MHz lot during a designated bid window (the single round).

A8.7 After the completion of the round, all bids are opened. The lot is awarded to the bidder with the highest bid that is equal to or exceeds a pre-specified reserve price.

A8.8 The price paid by the winning bidder is the amount of the second highest bid (or the reserve price, if there are no other bids), not the amount of their bid. This is known as a ‘second price’ rule. In the absence of significant concerns about competition or bidder asymmetries, a second price rule is likely to produce an efficient auction outcome, as bidders are able to express their full value in their bid. By contrast, with a first price (pay-what-you-bid) rule, bidders face the strategic complexity of shading down their bids based on their expectations of other bidders’ behaviour.

Detailed auction rules and procedures

A8.9 This section sets out key elements of the rules and procedures for implementing the proposed second price sealed bid format: transparency; pre-qualification rules; reserve prices; and deposits.

A8.10 Other issues that we will need to consider are: payments terms; default; collusion and bidder association; penalties; bid submission procedures; and unsold spectrum.

Transparency

A8.11 For any spectrum auction, it seems sensible to start from the presumption that all information should be revealed unless good arguments can be put forward why this could affect participants adversely and/or distort the current or future award processes. In general, revealing information is consistent with the principle of open government and may aid public confidence in the auction process.

A8.12 Transparency in a sealed bid auction concerns the type of information released to bidders before and after the auction. In short, there are two categories of possible information that could be released:

- the number and identity of bidders qualified to participate in the auction; and
- the results of the auction, including details of all bids submitted.

A8.13 For reasons explained in the following sections, Ofcom proposes the following approach to transparency in this auction:

- the identity of bidders qualified to participate in the auction is published; and
- at the end of the auction, only the identity of the winning bidder and the amount that they pay would be revealed (and by implication the identity of the losing bidders). No information would be released about the actual bids made until a later time.

A8.14 This approach reveals the most important information from the auction but does not reveal any more information about valuations than is necessary. This minimises any negative impact on bidders taking part in the subsequent 2.6 GHz auction that might otherwise discourage participation in this auction. At the end of the 2.6 GHz auction the bids made by the losing bidders in this auction would be revealed in full.

Number and identity of bidders

A8.15 The main concern about revealing information before the auction is that this might facilitate collusion between bidders to fix the result of the auction. Collusion in this auction would most likely take the form of one or more bidders agreeing to drop out of the contest, leaving a clear run for another bidder to pick up the licence cheaply. For example, this might take the form of a pre-auction merger between two aspiring PMSE band managers, which may be undesirable from a downstream competition perspective. Collusion is a feasible scenario given the potential scope for multiple PMSE users to share access to a licence.

A8.16 Ofcom's standard activity rules[126], however, contain provisions that would prohibit the types of collusive behaviour that are of concern in this auction. Therefore, Ofcom does not consider it necessary to restrict information about the identity of the qualified bidders for this purpose.

A8.17 Indeed, there may be some benefit in reducing common value uncertainty, as bidders will have an opportunity to re-evaluate their business cases in light of information about the number and type of competitors. This benefit may be modest, as the amount of information available will be limited and common value uncertainty may not be particularly important.[127]

Results of the auction

A8.18 At the end of the auction, Ofcom has a number of choices about the levels of information that it could reveal. At a minimum, it will release the identity of the winning bidder. In addition, it could release:

- the amount paid by the winning bidder;
- the amounts bid by all bidders.

A8.19 In general, releasing full information can aid public confidence in the auction process and facilitate analysis of the auction. Bid revelation may also aid the functioning of a secondary market in this and related lots. Therefore, the public interest arguments in favour of revealing the results in full are stronger than in the narrow case of considering whether to reveal information before the auction.

A8.20 Nevertheless, there are arguments against revealing the results. Second price auctions with full information reveal the maximum willingness to pay of all participants. In the case of this award, there may be concerns about linkages with the subsequent auction of 2.6 GHz and 2010-2025 MHz. Arguably, bidders planning to participate in both auctions could be at a disadvantage, as competitors might try to draw inferences from bids in this auction about potential valuations in the subsequent auction. This could act as a disincentive to participate in this auction.

A8.21 Ofcom considers that in order to avoid such disincentives in this particular case, it would be beneficial not to reveal any more information about the results than is necessary to identify the winner and its payments. At the end of the auction, the identity of bidders will already have been made public. However, it is not necessary to reveal information about the amounts or ranking of the losing bids, at least until the 2.6 GHz award has concluded. Not revealing this information may help to

[126] See Statutory Instrument 2006 No. 338 in respect of the award of 1781.7-1785 MHz paired with 1876.7-1880 MHz, available at http://www.opsi.gov.uk/si/si2006/20060338.htm, and Statutory Instrument 2006 No. 1806 in respect of the award of 412-414 MHz paired with 422-424 MHz, available at http://www.opsi.gov.uk/si/si2006/20061806.htm.

[127] The only likely bidders that have been identified are PMSE services. Common value uncertainty does not apply to bidders who would use PMSE to self-supply (e.g. TV producers such as the BBC and Sky), as they are serving separate 'markets'. Common value uncertainty would apply to competing band managers, assuming they intended to target the same PMSE users. To date, all PMSE demand has been channelled through a single band manager, JFMG, which has charged for spectrum use on a not-for-profit basis. Therefore, the emergence of a market-based band manager would be a significant innovation, and it is far from certain that more that one such bidder (if any) will emerge.

mitigate somewhat any negative impact on participants in subsequent auctions, in case some bidders in the award of the 2290 MHz band considered taking part in the award of the 2.6 GHz and 2010 MHz bands.

A8.22 A further possible concern with second price auctions is that the winning bidder typically pays less than the amount of its bids, potentially creating a mistaken perception that "value for money" has not be obtained from the auctioneer's point of view. However, this is not an adequate justification for restricting information about the winning bid and does not form part of Ofcom's reasoning for limiting transparency of the outcome, as Ofcom is concerned with fulfilling its statutory duties, not raising revenue. A second-price auction may leave 'money on the table', but the winning bid would not have been the same had the pricing rule been different.

Pre-qualification

A8.23 Ofcom proposes to follow its standard approach for sealed bid auctions and require a pre-qualification stage. This would provide an additional means to guard against collusion.

Reserve price

A8.24 Ofcom's policy in setting the reserve price (which is also the minimum bid in the auction) is to ensure that the auction only attracts serious bidders. As in previous auctions Ofcom proposes to set the reserve price at £50,000, a level which it considers is neither trivial nor high enough to risk the auction failing unnecessarily.

Deposits

A8.25 Deposits are upfront payments that will be forfeit if a bidder breaks specific auction rules or a winning bidder defaults on its payment. They help to deter frivolous bidders, similarly to reserve prices, and to reduce strategic incentives for default.

A8.26 Ofcom proposes to require two deposits: an initial deposit at the time of application; and a bid deposit. The initial deposit would be a proportion of the reserve price, for example 50%, i.e. £25,000. In the case of the bid deposit, Ofcom's approach for a sealed bid process is normally to set it so that the total deposit (initial and bid deposits) is equal to a certain proportion of each bidder's maximum bid. Given that Ofcom is uncertain about the value that bidders place on the licence, setting a deposit in this way is the only way to ensure that the deposit is sufficient to deter strategic default but not excessively onerous on bidders in the auction. Ofcom proposes to set this proportion at 100%.

Advantages and disadvantages of the candidate auction formats

A8.27 The table below provides a summary of the relative advantages and disadvantages of the two formats. In the absence of significant concerns about common value, the sealed bid, second price auction appears to be most advantageous.

Table 28: Relative advantages and disadvantages of the candidate auction formats for award of a single lot at 2290-2300 MHz

	Sealed bid, second price auction	**Ascending bid auction**
Common value uncertainty	No opportunity for bidders to learn by observing behaviour of others, though second price rule mitigates winner's curse. However, this is unlikely to be very important given that common value across bidders may be small.	Bidders can observe each other's behaviour. However, benefit is limited given that there is only one lot and common value across bidders may be small.
Bidder asymmetries	Efficient outcome likely even if bidders are asymmetric. Poor at constraining strong bidders to improve downstream competition, but this is not an obvious concern.	Efficient outcome likely even if bidders are asymmetric. Poor at constraining strong bidders to improve downstream competition, but this is not an obvious concern.
Collusion	Less vulnerable to collusion than ascending bid, especially if transparency is restricted.	More vulnerable to collusion than sealed bid, although restricting transparency would help.
Weak demand	More robust to low demand scenarios, especially if transparency is restricted.	Not as robust to low demand scenarios.
Speed of implementation	Auction complete in one round. Minimum possible time.	Auction may take several days to complete, depending on level of competition.
Cost of implementation	Low cost.	Requires more resources, including simple auction software.

Rules for combined auction of 2010-2025 and 2500-2690 MHz

Introduction and summary

A8.28 This section outlines a **combinatorial clock auction** format for the 2.6 GHz band (2500-2690 MHz) together with the 2010 MHz band (2010-2025 MHz).

What the auction design needs to consider

A8.29 There are particular challenges to achieving efficient use of this spectrum.

- The auction needs flexibility to accommodate bidders wanting different amounts of spectrum in the 2.6 GHz band. Unlike auctions such as the 2000 3G auction, spectrum cannot be pre-packaged with each winner receiving exactly one lot. Rather, the 2.6 GHz band needs to be sliced into smaller lots compatible with various possible uses, with bidders then assembling a number of lots to meet their requirements.

- Unless the auction is appropriately designed, bidders may face significant risks, e.g. that they acquire some spectrum, but it is not enough to meet their needs, or else spectrum that is insufficiently contiguous. Failure to award contiguous spectrum is a concern in the 2.6 GHz band, as this could sterilise use of the affected lots.

- There is significant potential for interference between neighbouring users in the 2.6 GHz band unless regard is given to how spectrum is likely to be used. This requires two different classes of usage right – one for paired spectrum (suitable for deploying FDD technologies) and one for unpaired spectrum (suitable for deploying TDD or unidirectional technologies or for pairing with a different band). The economically efficient split of spectrum between paired and unpaired use is uncertain. The auction, therefore, needs to determine whether a particular spectrum block is paired or unpaired.

- Spectrum at 2010 MHz could be either a substitute or even a complement for spectrum in the 2.6 GHz band.

- An open process is required to mitigate common value uncertainty and winners' curse. Bidders are likely to be serving a converging mobile data services market. Being able to check their own estimates of value against the behaviour of other bidders should allow information relevant to the valuation of spectrum to be aggregated across bidders and improve economic efficiency. Therefore, an open auction process is needed.

A8.30 Some of these challenges are not unique to this band. Allowing the market to determine how much spectrum each bidder gets by assembling smaller lots is an issue for a number of bands currently under consideration by Ofcom and has arisen in other spectrum auctions. Nevertheless, in the 2.6 GHz band it is particularly important to mitigate risks for bidders wishing to aggregate spectrum, while taking due account of demands for smaller amounts, because of the range of potential uses and the various amounts of spectrum associated to them.

A8.31 There has been considerable academic research into how to design auctions to mitigate aggregation risks. There is general consensus that where lots may be complements for some bidders, more efficient outcomes can be achieved with combinatorial auctions, where bids can be made for packages of lots. Package bids for multiple lots stand or fall in their entirety, so bidders do not face the risk of getting only part of the spectrum they need. There has been significant success with the use of sealed-bid combinatorial auctions, for example:

- by Ofcom itself for the 412 MHz band;

- in Norway in 2001 for GSM spectrum;

- in Nigeria in 2002 for fixed wireless spectrum;

- for rights to operate subsidised London bus routes.

A8.32 Use of open auctions with combinatorial bidding has been much more limited. The FCC proposed the use of a combinatorial SMRA for its C-band auction, though this auction was never run as the spectrum was withdrawn prior to the auction.

A combinatorial clock auction

A8.33 The approach proposed here is based on previous proposals for combinatorial SMRAs, but at the same time avoids the complications that have made such auctions tricky to implement. In particular, combinatorial SMRAs have two significant shortcomings:

- in each and every round they may require extensive information from bidders about their bids across many different packages of lots; and

- complex and non-transparent algorithms are required to translate bids for packages of lots in one round into minimum prices for individual lots to apply in the following round.

A8.34 We avoid these problems in these proposals by adopting some elements of a clock auction.

A8.35 A clock auction is a particularly simple form of SMRA in which bidders state how many lots they want at given prices. Price is increased where there is more demand than available supply. Clock auctions have typically been used where there are a number of identical lots that can be grouped into a small number of categories. For example, a clock auction was used for the UK Emission Trading Scheme auction in 2002.

A8.36 A simple clock auction would not be a good mechanism for awarding this spectrum. In particular, trying to apply a uniform price for all lots of a given type can sometimes lead to unsold lots if demand drops below supply. However, it is possible to add additional procedures to remedy this problem, as we describe below.

A8.37 The combinatorial clock auction proposed here brings together the simplicity of a clock auction with the superior efficiency properties of a combinatorial SMRA when some bidders treat lots as complements. We can achieve much of the benefit of a combinatorial SMRA without onerous requirements on bidders to make extensive bids or the need to run complex pricing algorithms each round.

Two-stage approach

A8.38 The 2.6 GHz band consists of a large number of similar spectrum blocks. We can exploit this feature to simplify the auction design dramatically. Because these blocks are similar, it is possible to use a two-stage approach:

- In the first stage – the **combinatorial clock stage** - bidders compete for generic lots that are not linked to any particular frequencies. This resolves how the 2.6 GHz band will be split between paired and unpaired uses and how many spectrum blocks bidders receive. This first stage itself consists of two sub-stages: a **clock stage** and a **best-and-final-offers stage**.

- In the second stage – the **assignment stage** - successful bidders from the first stage can express any preference they might have for particular frequencies.

A8.39 This two-stage approach with generic lots has been used in some spectrum auctions (e.g. the Italian 3G auction) where lots can be expected to be similar, yet bidders should still be allowed to express any particular preferences they might have for specific lots.

Available spectrum

A8.40 This section details the available spectrum, its packaging into lots and the definition of usage rights.

The 2010 MHz band

A8.41 Spectrum in the 2010 MHz band will be made available as a single 15 MHz lot on a technologically neutral basis. This approach is needed because of the difficulties in managing interference between different uses if the spectrum were made available in multiple lots of 5 MHz.

A8.42 Demand for spectrum at 2010 MHz can be expected to have some linkage with the 2.6 GHz band. Potentially, it could be either a complement or a substitute:

- For many bidders, spectrum at 2010 MHz would be a partial substitute to unpaired spectrum in the 2.6 GHz band. Although bidders could probably deploy similar applications as with unpaired spectrum in the 2.6 GHz band, the 2010 MHz band is not likely to be subject to the same degree of de facto standardisation across the EU, so equipment may be more costly and its availability more limited than for the 2.6 GHz band. On the other hand, propagation at 2010 MHz spectrum is better than at 2.6 GHz, therefore some bidders may view it as superior for particular applications.

- Spectrum at 2010 MHz could be used alongside unpaired spectrum in the 2.6 GHz band to provide additional capacity, possibly as a relatively cheap insurance against shortage of capacity in high demand scenarios given that it is likely to be somewhat inferior to 2.6 GHz spectrum. Therefore, for some bidders, it could be a weak complement for unpaired spectrum use in the 2.6 GHz band.

- Spectrum at 2010 MHz could be a complement with unpaired spectrum in the 2.6 GHz band for some bidders, as together they could be used to provide a non-standard duplex pair. Information available to date suggests that this is a remote possibility.

The 2.6 GHz band

A8.43 Ofcom has a general preference to issue usage rights that are technology and service neutral where possible. In the case of the 2.6 GHz band, it appears possible to accommodate all likely uses by awarding 5 MHz blocks that bidders can aggregate. However, awarding fully technologically neutral rights does not provide an efficient means of managing potential interference in this case[128]. Certain combinations of technologies are not compatible when used in adjacent 5 MHz frequency blocks. These interference problems occur only with particular combinations of adjacent uses and so it would be very wasteful to curtail the use of the spectrum to deal with the worst possible case. Resolving this problem requires differentiated usage rights for winning bidders intending to deploy different technologies. This allows the allocation process to take into account intended usage and not sterilise more spectrum for guard bands than is necessary.

A8.44 Following this approach, there will be two types of lot in the 2.6 GHz band with different usage rights:

- unpaired lots (5 MHz); and

- paired lots (2x5 MHz with 120 MHz duplex gap).

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[128] The auction is still technology neutral in that the split between paired and unpaired spectrum use is an outcome of the auction.

A8.45 Winners of these lots will need to be restricted from changing to an alternative technology without first reaching an agreement with neighbouring users.

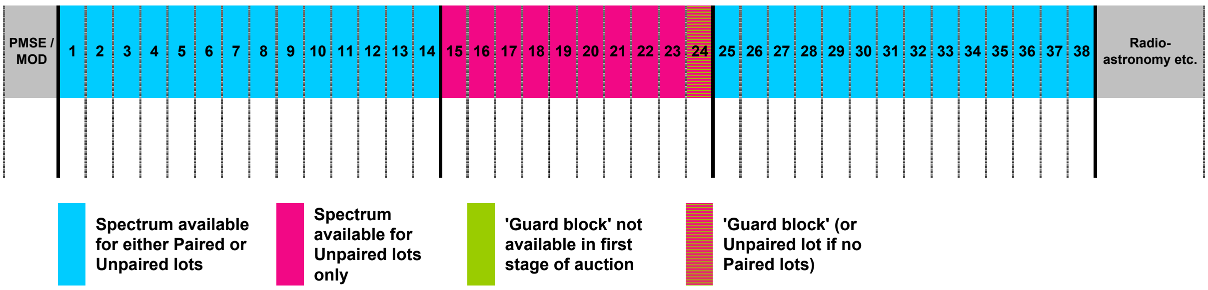
A8.46 Adjacent users of unpaired lots will need to be separated by a 5 MHz guard band. Bidders will need to acquire the 5 MHz block needed to act as a guard band along with the spectrum used for deploying services. Therefore, a winning bidder will need to acquire two or more unpaired lots to deploy a wide-area service. In practice, bidders are likely to need more lots than this to provide sufficient capacity for services.

A8.47 Adjacent users of paired lots are easier to accommodate, as with appropriate definition of usage rights it is not necessary to separate adjacent users of paired spectrum. However, 5 MHz guard blocks still will be required to separate adjacent users of paired and unpaired spectrum to avoid undue interference.

Trade-off between numbers of paired and unpaired lots

A8.48 There are 38 blocks of 5 MHz in the 2.6 GHz band, as illustrated in Figure 32, of which between 36 and all 38 would be available for award configured as paired lots or unpaired lots. The total number of lots available depends on how the spectrum is divided up between paired and unpaired use, as this affects the need to withdraw 5 MHz blocks as guard bands.

Figure 32: Overview of available spectrum



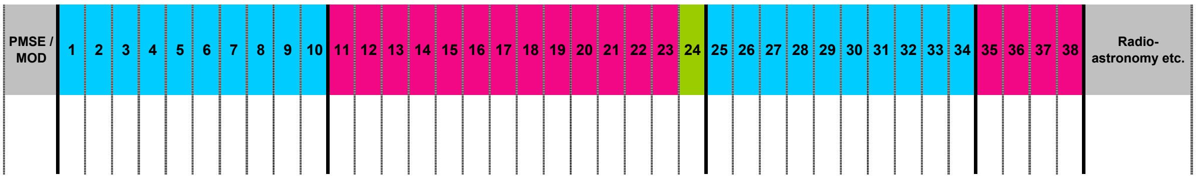
A8.49 There is a trade-off between the number of paired and unpaired lots, as paired lots can be broken down into their constituent 5 MHz blocks to give additional unpaired lots. The number of lots available in each category is between:

- 9 and 38 unpaired lots; and
- zero and 14 paired lots.

A8.50 Figure 32 above illustrates the boundary between paired lots (blue) and unpaired lots (red) in the case that the minimum number of unpaired lots is awarded. There are 9 unpaired lots and 14 paired lots in this case.

A8.51 If demand for unpaired lots in the auction is sufficient to displace some paired lots, then the lower boundary of the unpaired lots moves downwards from 2570 MHz, creating additional unpaired spectrum at the expense of paired uplink spectrum. This situation is shown in Figure 33 below, which illustrates the example in which 4 paired lots have been broken down to give additional unpaired lots. This has the effect of also freeing up corresponding paired downlink spectrum at the top of the band below 2690 MHz, allowing the creation of further unpaired lots from lot 38 down. We call the unpaired lots from 38 down the **upper unpaired area**, as opposed to the **lower unpaired area** from lot 23 down.

Figure 33: Example of converting Paired Lots to Unpaired Lots



A8.52 Typically, for each paired lot that is lost, an additional two unpaired lots can be created, one in the lower unpaired area and one in the upper unpaired area. There are two exceptions to this rule:

- In the case that a single paired lot is converted to unpaired spectrum, then there would not be sufficient spectrum in the upper unpaired area to be able to use this single unpaired lot and have an adequate separation from an adjacent paired user. Therefore, only one additional unpaired lot is created (in the lower unpaired area only in this case), rather than two. In this particular case, only 36 of the available 38 blocks of 5 MHz are awarded.

- In the case that all spectrum is awarded to Unpaired Lots, then there is no longer a requirement for a guard block between paired and unpaired use. In this case, an additional Unpaired Lot can be awarded.

A8.53 Table 29 below lists all the possible combinations of paired and unpaired lots that could feasibly be awarded.

Table 29: Possible combinations of Paired and Unpaired lots

Outcome	Unpaired lots			Paired lots			Guard Blocks
	Total no. unpaired lots	Lower unpaired area	Upper unpaired area	Total no. paired lots	Uplink	Downlink	
1	9	lots 15-23	-	14	lots 1-14	lots 25-38	lot 24
2	10	lots 14-23	-	13	lots 1-13	lots 25-37	lots 24&38
3	13*	lots 13-23	lots 37-38	12	lots 1-12	lots 25-36	lot 24†
4	15*	lots 12-23	lots 36-38	11	lots 1-11	lots 25-35	
5	17*	lots 11-23	lots 35-38	10	lots 1-10	lots 25-34	
6	19*	lots 10-23	lots 34-38	9	lots 1-9	lots 25-33	
7	21*	lots 9-23	lots 33-38	8	lots 1-8	lots 25-32	
8	23*	lots 8-23	lots 32-38	7	lots 1-7	lots 25-31	
9	25*	lots 7-23	lots 31-38	6	lots 1-6	lots 25-30	
10	27*	lots 6-23	lots 30-38	5	lots 1-5	lots 25-29	
11	29*	lots 5-23	lots 29-38	4	lots 1-4	lots 25-28	
12	31*	lots 4-23	lots 28-38	3	lots 1-3	lots 25-27	
13	33*	lots 3-23	lots 27-38	2	lots 1-2	lots 25-26	
14	35*	lots 2-23	lots 26-38	1	lot 1	lot 25	
15	38	lots 1-38		0	-		

* Actual number of unpaired lots would be 1 less than this in the event that there is a winner of unpaired spectrum who must receive a split assignment, which we explain subsequently.

† In the event that a winner of unpaired spectrum must receive a split assignment, there will be an additional guard block located somewhere within the upper band.

A8.54 Figures 34 to 36 below illustrate three examples of the possible outcomes, showing how the number of unpaired and paired lots changes as we move from outcome 2 to outcome 4.

Figure 34: Paired and Unpaired lots available in outcome 2

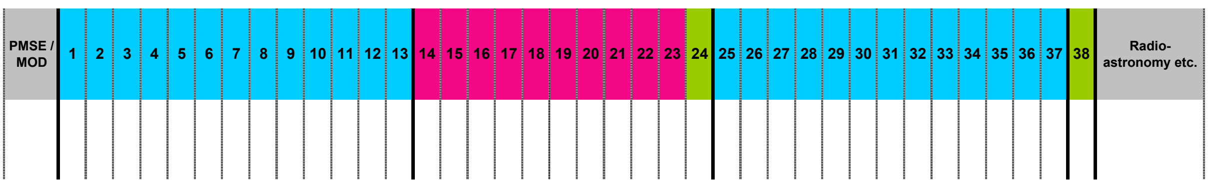


Figure 35: Paired and Unpaired lots available in outcome 3

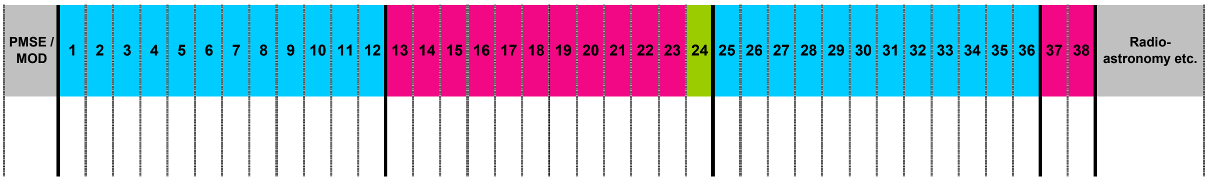
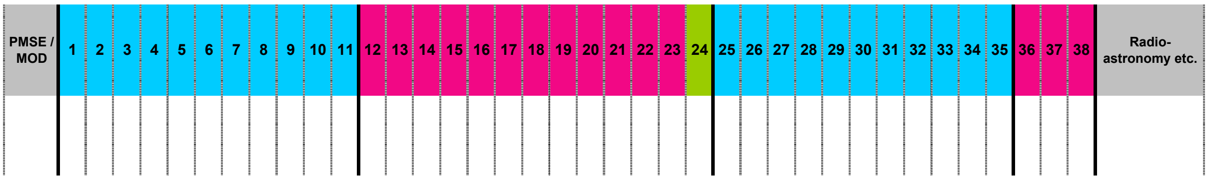


Figure 36: Paired and Unpaired lots available in outcome 4



Interference management and guard blocks

A8.55 In order to prevent undue interference between adjacent users of unpaired lots and between adjacent users of paired and unpaired lots, it is necessary to have a 5 MHz separation. This is achieved in two ways:

- For each winner of unpaired spectrum, the lowest frequency lot awarded would be subject to usage restrictions designed to protect adjacent users of whatever type.[129] The de facto implication of this is that the lot would primarily be used as a guard band, although some low-power uses may be possible, or some high-power use on a geographically limited basis, subject to negotiation with neighbouring users.

- Either one or two of the 38 lots would be designated as guard blocks and would be not be available for allocation in the first stage of the auction:

    - Lot 24 (in all cases, except where all spectrum is awarded as unpaired lots);

    - Lot 38 (only in the case that exactly one paired lot is converted to an unpaired lot and 10 unpaired lots are awarded, as there is insufficient spectrum in the upper unpaired area to allow a guard block between paired and unpaired spectrum use); and

    - one further lot between lots 26 and 37 inclusive (only in the case that there is a winning bidder for unpaired lots that receives a split award of lots in both the upper and lower unpaired areas, which we explain below).

A8.56 An immediate implication of this approach is that bidders for unpaired lots cannot bid for less than two unpaired lots, as their lowest frequency lot is always subject to usage restrictions. This ensures that they always win at least one block not encumbered by additional restrictions to prevent interference to adjacent use. Bidders may bid for a single paired lot.

A8.57 Figures 37 to 39 below illustrate three examples of potential awards to bidders. Each winning bidder receives contiguous spectrum, apart from in the case of a split award of unpaired lots, in which one bidder must receive some spectrum in the upper unpaired area and some in the lower unpaired area.

[129] This rule places the primary cost burden of coordination entirely on unpaired lot winners, which seems reasonable given that paired lot winners can coexist with each other in adjacent spectrum.

Figure 37: Example 1, spectrum allocated as in outcome 2 with no split award

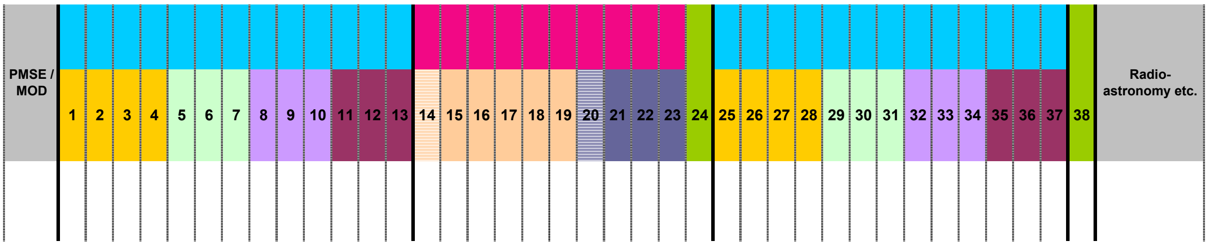


Figure 38: Example 2, spectrum allocated as in outcome 6 with a split award

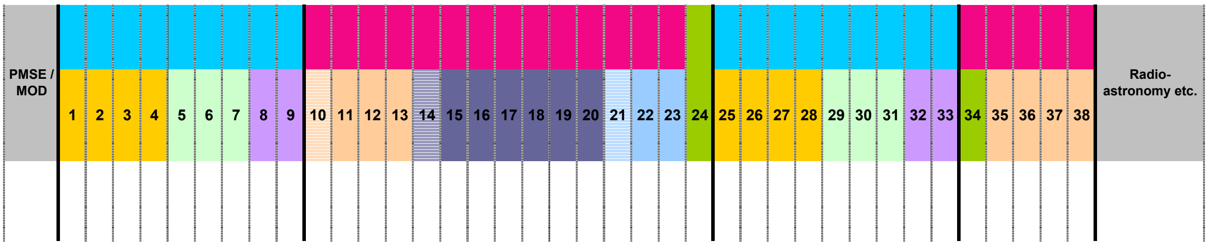
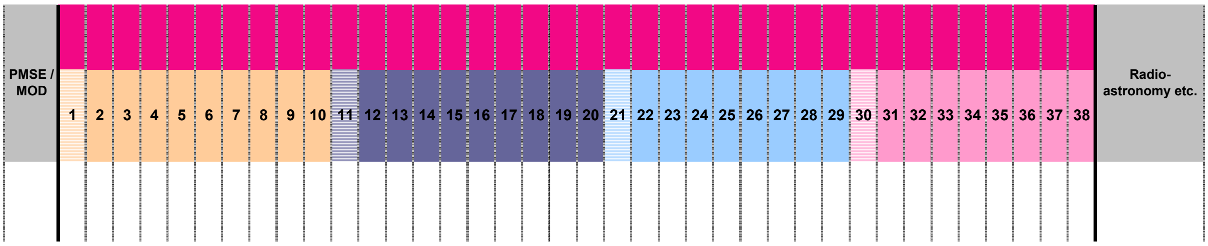
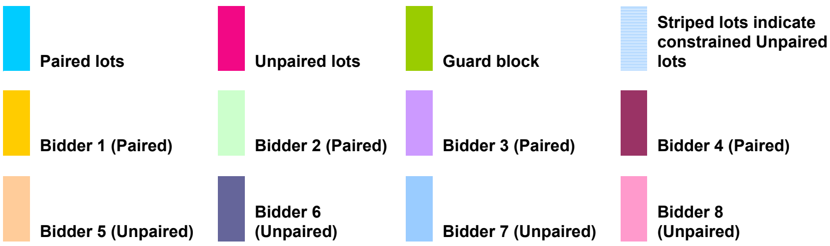


Figure 39: Example 3, spectrum allocated as in outcome 15 with no split award





A8.58 It is possible to make guard blocks available for award on a restricted usage basis. This is simplest if this spectrum Is offered to those holding adjacent spectrum. We describe later how the auction process can be structured to achieve this.

Contiguity and split award of unpaired Lots

A8.59 As far as possible, winning bidders would be awarded contiguous spectrum:

- Winning bidders that win more than one paired lot can always be awarded paired contiguous spectrum.

- Winning bidders for unpaired lots can often be awarded contiguous spectrum, with one exception. It is possible that one unpaired lot winner would need to receive spectrum in two separate blocks, one in the upper unpaired area and one in the lower unpaired area. We call this case a **split award**.

A8.60 In the case of a split award, we say that an unpaired lot winner receives **upper and lower unpaired area blocks**. We discuss the worst case of fragmentation in detail below, but in summary:

- only one bidder need receive unpaired lots in two blocks;
- each block is contiguous within itself;
- in the lower unpaired area block, there will be at least two lots (though the lowest of these will be subject to usage restrictions, in the same way as assignments of unpaired lots to any other winner will be);
- in the upper unpaired area block, there would be a least one lot, but fully usable with a protective guard block below it.

Overview of the award process

A8.61 We first provide a brief overview of the entire award process before considering the detailed rules.

A8.62 Ofcom is proposing a two stage-process for the award of spectrum:

- a first stage consisting of a **combinatorial clock auction** of **generic lots** within the 2.6 GHz band and (simultaneously) the single 2010-2025 MHz lot; followed by
- a second **assignment stage**, consisting of a combinatorial sealed bid auction, leading to the award of **specific lots** relating to frequency blocks within the 2.6 GHz band.

A8.63 The first stage determines the amount of spectrum that is allocated to either paired or unpaired lot in the 2.6 GHz band, the identity of the winning bidders and the numbers of lots in various categories that they receive. The second stage determines the specific frequencies that are assigned to each winner of the first stage.

The first stage – the combinatorial clock auction

A8.64 In the first stage, lots in the various categories are sold on a generic basis, i.e. they entitle winning bidders to a certain number of lots of a particular type but, in the 2.6 GHz band, no particular frequency is guaranteed. The use of generic rather than specific lots in the first stage is fundamental to this auction design, as it makes it possible to manage the separation of paired and unpaired users efficiently by making sure that winners receive contiguous spectrum as far as possible. Were specific lots used in this stage, there would be a risk that the market would fail to produce an efficient distribution of paired and unpaired lots amongst winning bidders.[130]

A8.65 For the first stage of the auction, a form of simultaneous multiple round auction (SMRA) is proposed that we call a **combinatorial clock auction**. This has two sub-stages:

[130] Even allowing combinatorial bidding, there is little guarantee that a conventional SMRA would lead to efficient outcomes.

- a **clock stage**;
- a **best-and-final-offers stage** that may be run depending on the outcome of clock stage.

A8.66 In the clock stage we ask bidders to state their most preferred package of lots at given prices. Where there is excess demand, prices are increased in the following round. This process proceeds through multiple rounds.

A8.67 Although there are three categories of lots (paired and unpaired lots at 2.6 GHz and the single 2010 MHz lot), in this particular case we only need two clock prices:

- one for 5 MHz blocks of 2.6 GHz spectrum (the **2.6 GHz clock**); and
- one for the single 2010 MHz lot (the **2010 MHz clock**).

A8.68 Prices across paired and unpaired lots can be linked, because the potential supply of each type of lot is closely interlinked. Typically, there would be a 2:1 price ratio between the price of paired and unpaired lots, reflecting that one paired lot can usually be broken down to give two unpaired lots.

A8.69 The number of paired lots on which bidders can make bids cannot increase from round to round. Similarly, the number of unpaired lots on which bidders can make bids cannot increase from round to round. The single 2010 MHz counts as equivalent to two unpaired lots for these purposes. These **activity rules** force bidders to bid according to their preferences, rather than waiting until the end of the auction to reveal their hand, facilitating price discovery.

A8.70 To allow bidders to reflect more fully the preferences they might have about substitute combinations of lots (e.g. 2010 MHz as a substitute for unpaired spectrum at 2.6 GHz), we include certain elements of a combinatorial SMRA.[131] In particular, at any point in the auction at which a bidder reduces its eligibility to make future bids, it may make **best and final offers** for all those packages of lots on which the bidder will not be able to bid thereafter. Therefore, bidders are not limited simply to indicating only their most preferred package of lots in each round as with a simple clock auction. However, best and final offers are not considered until the best-and-final-offer stage; they have no effect on the conduct of the clock stage.

A8.71 Best and final offers may not exceed the relevant clock prices in the rounds in which they are made. This means that best and final offers cannot be used to “jump ahead” of the clock price. Rather, clock prices increase progressively and there is an orderly price discovery process.

A8.72 As clock prices rise, bidders will be willing to bid on fewer and fewer lots, making best and final offers as they go along. Eventually, clock prices will have risen sufficiently that there is no longer any excess demand for lots. At this point, the clock stage stops.

[131] In a typical combinatorial SMRA, in each round a bidder would be able to make bids for a number of different packages of lots, choosing a price for each package. Therefore, there is a much richer expression of preferences, since the bidder is potentially indicating the relative attractiveness of different combinations of lots at different relative prices. In contrast, in a clock auction bidders simply indicate their most preferred package of lots at given prices.

A8.73 If there are no unallocated lots at the end of the clock stage (i.e. demand exactly matches supply), then the first stage of the auction concludes with the remaining bidders winning the relevant number of generic lots at the final clock prices. Given the stated preferences of bidders, this is an efficient outcome as each winner is bidding for its most preferred package of lots at the final clock prices and those not gaining lots have already dropped out of the clock process as prices have exceeded their willingness to pay.

A8.74 If there are unallocated lots at the end of clock stage, then we move to the **best-and-final-offers stage.** Remaining bidders at the end of clock stage make their best and final offers on those packages on which they are still eligible to bid. Then, the auctioneer considers all the bids made in the course of the auction, including all the most preferred bids from the clock stage and all best and final offers. The set of bids of greatest total value is identified, subject to each lot being awarded at most once and at most one bid being accepted from each bidder. This determines the first stage outcome.

A8.75 In the best-and-final-offers stage, the price to be paid by each winner for the package of lots that they have won is determined by a **second price rule**. Each bidder pays the minimum amount necessary such that no other bidder or group of bidders would be prepared to make a counter offer for lots that would be preferred by the group and give at least as much revenue. This ensures that those bidders remaining at the end of open bidding phase have incentives to make bids fairly close to their true values rather than to shade their bids, as would happen if they simply paid what they bid.

The benefits of this approach

A8.76 This format is effectively an amalgam of a clock auction and a combinatorial auction. It resolves various problems that occur with these two auction formats.

A8.77 A problem with a standard combinatorial SMRA (for example as proposed by the FCC) is that the process for determining prices from one round to the next is complex and non-transparent. In the combinatorial clock auction, prices are determined simply by increasing the clock prices for categories of lot where there is excess demand according to bidders' statements of their most preferred packages of lots. This is a significant simplification.

A8.78 Unlike a simple clock auction, bidders are given free rein in the combinatorial clock auction to express demand for any packages of lots they are interested in, provided that this is consistent with the open bidding phase. However, unlike a conventional combinatorial SMRA, it is not necessary for bidders to list out bids for all packages they might potentially want in each and every round. Best and final offers are only possible where bidders are in a situation where their future ability to make such offers will be lost after the current round.

A8.79 In the best-and-final-offers stage, we look for the most efficient allocation of lots given all the bids received so far. Even where some bidders have strong complementarities across lots, this format should produce a high level of economic efficiency. Bidders are not exposed to any aggregation risks, as their bids are for packages of lots that stand or fall in their entirety.

A8.80 A significant problem with simple clock auctions is that of "overshooting" where demand can drop to strictly less than supply as price is increased. There could be excess demand at one price, but excess supply at any higher price. Under these circumstances, there is no market-clearing price and it is impossible to allocate all lots at the same price. Nevertheless, it may often be possible to allocate otherwise unsold lots at a lower price than that set at the end of clock auction (although there is no guarantee of this). To determine whether this is possible, we need information about bidders' willingness to pay for packages of lots other than those received at the end of clock auction. Best and final offers expressed in earlier rounds provide exactly this information without undermining the price discovery process.

A8.81 A further problem with a simple clock auction is that bidders substituting across different categories of lots may not have been able to indicate all the possible packages of lots they would be prepared to accept. This can happen if bidders can only indicate their most preferred combination of lots at each round. For example, a bidder might be prepared to substitute 2010 MHz spectrum for 2.6 GHz, but might never have bid for 2010 MHz spectrum if the relative price of the 2010 MHz was sufficiently high relative to 2.6 GHz spectrum whilst the general level of prices was still low enough that the bidder wanted to participate. In contrast, best and final offers allow bidders to express their preferences over various substitute combinations. This ensures that those bidders wishing to substitute across different categories of lot can do so.

The second stage – the assignment stage

A8.82 The first stage of the auction determines the split of the 2.6 GHz spectrum between paired and unpaired lots and the number of lots that each bidder will receive. The only remaining question is which frequencies will be allocated to the first stage winner. This is achieved through an **assignment stage**.

A8.83 Although as a first approximation we can take paired and unpaired lots as being similar and close substitutes (within each category), there may be minor differences between them. In particular, the value of the blocks in the lower unpaired area may differ from those in the upper unpaired area, as the former is more likely to benefit from economies of scale in equipment given similar use in other EU countries. There may also be small differences in the value of paired lots close to the boundary with the unpaired lots to the extent that these could be adversely affected by interference.

A8.84 For the second stage, Ofcom would prefer to give bidders the opportunity to express any preference they might have for particular frequencies, rather than the allocation of specific frequencies being achieved through an administrative or random process.

A8.85 The assignment stage would be conducted through a sealed-bid combinatorial auction. Winning bids from the first stage give rise to corresponding commitments in the second stage. For example, if a bidder won three generic unpaired lots in the first stage at a certain price, this entails a commitment to bid for all contiguous sets of three unpaired lots at specific frequencies available in the second stage at this price. Bidders would be able to make top-up bids for particular frequencies above this base price to express any preferences they might have for particular frequencies.

A8.86 It is possible to organise the assignment process such that only contiguous spectrum awards result or at worst one bidder receives unpaired spectrum in two contiguous blocks (the **split award** described above). This can be achieved by limiting the packages of frequencies on which bids can be made to those that are compatible with contiguous blocks.

A8.87 Given these top-up bids, we determine the allocation of specific frequencies to bidders that maximises the total value of accepted bids, subject to allocating each lot to at most one bidder and accepting at most one bid from each bidder.

A8.88 There are various possible ways to determine the prices that bidders pay at the end of the assignment stage. We propose that bidders pay the first stage price for the relevant generic lot, plus the value of their successful top-bid for a specific frequency block.

Key issues for the overall award process

A8.89 In this section, we briefly list the main issues that need to be addressed by the proposed auction design. These are:

- the trade-off in the number of paired and unpaired lots at 2.6 GHz;
- achieving contiguous spectrum for each bidder (as much as possible);
- how additional guard bands are dealt with in a split award;
- complementarities and substitution between lots; and
- common value uncertainty.

Paired/unpaired trade-off

A8.90 As described above, there is a trade-off between the number of paired lots and unpaired lots that can be awarded (see table 29). This is an unusual feature of the award process. However, it is unavoidable given that it does not appear to be possible to define a single class of usage right that would allow these various uses to co-exist and also make efficient use of spectrum.

A8.91 The appropriate balance between paired land unpaired lots is uncertain, and will depend on the relative business cases of bidders planning to deploy different technologies and applications. It is not possible to predetermine the split between paired and unpaired use, as we have no reliable information about relative demand. Therefore, we require an auction design that can allow the market to determine the amounts of spectrum allocated to each use.

Contiguity issues

A8.92 Given an appropriate definition of usage rights, users of paired spectrum can be also packed together without causing undue interference with each other. However, to prevent undue interference a ‘guard band’ (a 5 MHz block) is required between adjacent users of unpaired lots and also between adjacent users of paired and unpaired lots.

A8.93 Maximising the amount of usable spectrum available for applications requires minimising the number of boundaries between paired and unpaired lots, and between unpaired lots held by different users, as each boundary creates an additional need for a guard block. This means that it is particularly important to assign spectrum in contiguous blocks.

A8.94 There is a strong case that the minimisation of the number of guard bands should be imposed as an intrinsic feature of outcomes of the award process, rather than allowed to emerge from amongst a broad range of possible outcomes through market forces. Although bidders have clear incentives to acquire contiguous spectrum, achieving efficient packing of different users' requirements is likely to require coordination of the decisions of multiple bidders. Thus a traditional SMRA is inappropriate for the 2.6 GHz band, as it may be unreliable in producing outcomes where sterilisation of spectrum due to guard bands is minimised. In a typical SMRA for specific frequencies it might be difficult for a bidder seeking multiple contiguous unpaired lots to switch to a different set of lots in order for likely winners' demands to fit together better in the available spectrum. Moreover, in such an auction, bidders might even have an incentive to bid in a manner aimed to frustrate other bidders packing efficiently into the available spectrum.

A8.95 We address this issue by using the first stage to determine both the split between paired and unpaired lots and the number of generic lots each bidder wins. The second stage determines which precise frequencies winners obtain, but we constrain this process to ensure that contiguity of spectrum holdings is maximised and the loss of spectrum to guard bands minimised.

Who pays for the extra guard band in a split award?

A8.96 In the case that one of the unpaired lot winners receives a split award, it will be necessary to constrain the use of one lot at the bottom end of both their upper and lower unpaired area blocks to provide guard bands with adjacent users. This raises the question of whether a bidder receiving spectrum in a split award might be penalised relative to other bidders if, not only receiving spectrum in two blocks, it also has to pay for two guard blocks.

A8.97 There are two natural approaches to dealing with the additional guard block required if there is a split award:

- impose constraints on the lowest frequency lot in **both** the upper and lower blocks which the winner subject to the split award must buy; or
- impose constraints only on the lowest frequency lot in the lower block but set aside an additional unpaired lot as a 'guard block' in spectrum immediately below the upper block.

A8.98 Although the first approach is more straightforward in terms of auction design, it may create uncertainty for bidders. In particular, bidders cannot anticipate whether or not they might be subject to a split award. This depends on how many unpaired lots other winners demand and whether winning bids can be packed neatly into the lots available in the upper unpaired area. A split award would significantly reduce the value of spectrum relative to winning a single contiguous block, as that bidder would have two constrained unpaired lots rather than one.

A8.99 It might be tempting to try to mitigate the problem by applying the split award to the bidder who wins the most unpaired lots. This has the advantage that the bidder with the most lots is proportionately less affected by having to buy two guard bands. However, it is possible there are a number of winners all having the same number of unpaired lots (in which case there is a fairness issue about which one is subject to a split award) or that all winners have few unpaired lots (in which case the impact of one versus two lots having restricted usage rights is still material). Therefore, this is not a sufficient solution to the problem of penalising the bidder subject to a split award.

A8.100 The second approach is more complex, as it requires us to withdraw a lot from the auction when a split award is necessary. This means flexing the number of unpaired lots available in the auction in response to particular patterns of demand. Nevertheless, it avoids this uncertainty for bidders and may, therefore, produce a more efficient outcome. The proposed auction rules follow this second approach.

Complementarities

A8.101 This auction is likely to demonstrate significant complementarities for bidders in winning multiple spectrum blocks. This appears to be important for unpaired blocks, where a sufficient number would be required to provide a workable service. Bidders' demand is likely to drop discretely from a number of blocks to zero as prices increase. It is important that the award process manages bidders' aggregation risks adequately to ensure that fragmented outcomes are not created in which winners obtain some spectrum, but not enough to offer services. Such outcomes would lead to inefficient use of spectrum.

A8.102 Whilst we would expect that complementarities will be most significant between multiple unpaired lots at 2.6 GHz, it is also possible that they could arise between unpaired lots at 2.6 GHz and the 2010 MHz lot (for example, because a certain minimum amount of capacity is needed or to create a non-standard duplex pairing). There could also be complementarities amongst multiple paired lots if bidders need a certain minimum number of lots to provide capacity.

A8.103 A standard SMRA is inappropriate in these circumstances and we must include some mechanisms to ensure that bidders can manage aggregation risks. We address this in both stages of the auction, by allowing bidders to express their demands in terms of packages of lots. Bidders can only win packages of lots for which they have expressed demand. These packages are never subdivided.

A8.104 Clock auctions include package bidding as an intrinsic feature, in that bidders are asked to state their most preferred package of lots at given prices. If the clock auction concludes, this bid is successful in its entirety, whereas if the auction continues bidders get to state another most preferred package.

A8.105 A complication is that we also wish to gather best and final offers at points where bidders reduce their eligibility to bid. However, even in this case, we ask bidders to state their willingness to pay for packages of lots and so aggregation risks are avoided. Therefore, the proposed combinatorial clock auction *entirely* removes aggregation risks for bidders.

Substitution possibilities

A8.106 For many bidders, many of the available frequencies will be perfect substitutes: For example, most of the paired lots are largely identical for bidders, though there may be minor differences in the characteristics of paired lots close to the boundary with unpaired spectrum.

A8.107 It is important that bidders are able to pursue these substitution possibilities within the auction. We deal with this by allowing bidders to bid for generic categories of lots in the first stage of the auction. To the extent that these lots are in fact imperfect substitutes, there is an opportunity for bidders to express this in the assignment stage.

A8.108 There are potential substitution possibilities between the 2.6 GHz unpaired spectrum and the 2010 MHz lot. Therefore, we need to allow for bidders to switch demand between these two categories in response to changing relative prices. This requires that appropriate flexibility be built in to activity rules.

A8.109 There can be problems with simple clock auctions with multiple categories of lots that are substitutes. Bidders may not have bid on all combinations that are substitutes by the end of the auction if only asked for their most preferred package at given prices. If bids made in intermediate rounds are considered for the purposes of allocating any remaining lots at the end of the clock auction, we may still have only partial information about the packages that bidders are prepared to accept.

A8.110 Whilst there may be some concerns about efficiency as a result, the more significant problem is that bidders prepared to substitute between categories are limited in their ability to express their preferences and so could be perceived as being discriminated against. The combinatorial clock auction removes this problem by allowing bidders an opportunity to represent all of their substitution possibilities at points in the auction when they reduce their eligibility.

Common value uncertainty

A8.111 It is reasonable to expect there to be significant common value uncertainty in this auction. The most important applications are likely to be use of the spectrum for mobile networks (either for expansion or possibly even entry by MNOs) or wireless broadband type applications. Research carried out for Ofcom concluded that many of the technologies that could be deployed in this band are aimed at the converging market for provision of mobile data services[132], and that there is a high degree of uncertainty over the pace and scale of future demand in this area. Under these circumstances, bidders may reduce uncertainty about their own valuations by being able to observe how their competitors change their demands in response to changing prices.

A8.112 Given this, it is important to use an open process to permit price discovery. An important function of any economic market is the pooling of information about the value of what is being traded. In situations of common value uncertainty, auction theory has demonstrated that the efficiency of auction outcomes will be augmented if bidders are able to observe the behaviour of their rivals over the course of multiple rounds, subject to concerns about not facilitating collusion.

A8.113 Given our assumption that we can categorise lots such that they are fairly similar within each category, it follows that most of the common value uncertainty will be resolved in the combinatorial clock auction, rather than the assignment stage. Furthermore, it may be that preferences for specific frequencies are idiosyncratic to particular bidders, further decreasing the importance of common value uncertainty in the assignment stage. Therefore, it is reasonable to use an open process for the first stage where price discovery is important, but a simpler sealed bid for the assignment stage when bidders need to express more complex preferences.

A8.114 With regard to the clock stage, there is a question about how much information is required by bidders to draw inferences and reduce the impact of common value uncertainty. Transparency could be limited to reporting only the total demand in each category at the end of each round. However, the difficulty with limited

[132] The leading candidate uses are: 3G mobile services, using UMTS FDD technology; and wireless broadband, using WiMAX or another TDD technology.

transparency is that it is not possible for bidders to observe the behaviour of other bidders who might have similar applications in mind. For example, a bidder intending to provide wireless broadband using unpaired spectrum at 2.6 GHz would specifically benefit from seeing how the demand of other bidders with similar planned applications changes as price changes. This suggests that full transparency is desirable providing there are no countervailing concerns about collusion. This would include transparency on best and final offers.

A8.115 A compromise between full transparency and revealing only excess demand would be to release details about the number of lots each bidder requested in each category, but on an anonymous basis. It is difficult to judge how useful such information might be to bidders, but it seems likely that they could draw some inferences. For example, a bidder for both paired and unpaired lots would more likely be a MNO than a wireless broadband entrant. This approach would allow useful information to be gleaned about competitors' actions, whilst significantly frustrating collusion, as there would be no easy way to see what any particular bidder might be doing. This might be a good compromise if there are some concerns about possible collusion, but these concerns are not severe.

Bidder asymmetries and weak competition

A8.116 Clearly existing MNOs may have rather different reasons for participating from other bidders, in that they are likely to be seeking spectrum for 3G expansion. However, there is nothing to suggest that MNOs will have general and systematic advantages over, say, those seeking spectrum to deploy new wireless broadband services. There is a considerable amount of spectrum in the 2.6 GHz band and this is likely to be sufficient to accommodate a variety of users.

A8.117 So far, there is no evidence to suggest that the auction design needs to accommodate the possibility of weak competition due to asymmetric bidders. If this were the case, then it would be possible to terminate the clock stage earlier and bring a greater role for best and final offers. However, this may compromise the price discovery process achieved with an open auction.

Residual uncertainties

A8.118 We have assumed that differences between lots are not sufficient to preclude treating lots as three categories (paired, unpaired and the 2010 MHz lot) for the purposes of the combinatorial clock auction. Given this assumption, the overall efficiency of the award is primarily dependent on the combinatorial clock auction. Having a follow-up assignment stage can improve the efficiency of the outcome, but it cannot resolve any substantial inefficiencies that might occur in the outcome of the combinatorial clock auction if there were large valuation differences between lots in the same category.

A8.119 There are three remaining technical uncertainties potentially affecting this categorisation of lots:

- Depending on the pattern of demand across bidders for unpaired spectrum, it may be necessary to make a split award to one winning bidder, with some spectrum in the lower unpaired area and some in the upper unpaired area. This is likely to be less desirable for a winning bidder than receiving a single award of contiguous spectrum.

- We have assumed that there is no material difference in the value of unpaired spectrum whether it falls in the centre 45 MHz (as per the CEPT band plan) or not. However, it is plausible that an operator may value the centre 45 MHz significantly more than other unpaired spectrum because of de facto standardization of equipment.

- It may be necessary to impose an additional out-of-band mask for base stations based on the 3GPP pico cell mask (i.e. a low-power restriction) for those channels either side of the severely restricted 'guard band' lots. This could devalue such channels. This may not be a problem for boundaries between adjacent unpaired lot users as the restriction is symmetrical across the boundary. However, it may be a problem for the boundary between the paired downlink and the unpaired lots, because the paired spectrum user with such a boundary would have a significant restriction that would not apply to other paired spectrum users.

A8.120 In all three cases, it is possible for bidders to express preferences in assignment stage of the auction. However, if there were significant valuation differences affecting many lots, this would create risks for bidders in the combinatorial clock auction, as they could not anticipate the outcome of the assignment stage. Therefore, if there was evidence to suggest that valuation differences amongst the generic paired and unpaired lots were sufficiently large, there might be a need to subdivide these categories. A similar auction format could be used even if more categories of lots were needed.

Key issues for the first stage

A8.121 Before turning to the detailed rules for the first and second stage, we first consider the key issues that the first and second stages of the auction need to address.

Unallocated lots

A8.122 In a clock auction, a major issue is that the imposition of uniform linear pricing (i.e. every block in a category has the same price) may lead to unsold lots and inefficient outcomes. A simple example of a clock auction of 10 lots illustrates the point. Suppose that:

- bidder A wanted 10 lots at a maximum price of £10 per lot; whereas

- bidder B wanted 2 lots at a maximum price of £12 per lot.

A8.123 The efficient outcome is clearly for A to win, as this bidder has a total willingness to pay of £100. However, in a clock auction, there is excess demand at any price less than £10 per lot. Once the price exceeds £10 per lot, A drops out and B wins. This leaves 8 lots unsold and is inefficient.

A8.124 If we optimise over the bids made in the course of the auction (subject to allocating each lot at most once and taking at most one bid from each bidder), then all the lots would be awarded to bidder A. However, for this optimisation step to produce efficient outcomes, the bids received need to reflect each bidders' maximum willingness to pay.

A8.125 In the simple example above, bidder A has expressed its maximum willingness to pay before dropping out of the clock auction. More generally, even with multiple categories of lots, provisions for best and final offers in the clock combinatorial auction allow any bidder who has dropped out of the clock stage (or reduced their eligibility) to express their maximum willingness to pay on all relevant packages of lots.

A8.126 The clock stage will not have revealed the maximum willingness to pay of those bidders still remaining at the end of the clock stage. In the example above, bidder B has not revealed that it is willing to pay £12 per lot, as the clock price stopped at £10. In this example, this does not matter, but if bidder B was prepared to pay significantly more (say £60 per lot), then optimising over the bids received in the clock stage would not produce an inefficient outcome. B would be prepared to pay more in total but had not yet expressed this. Therefore, we need to allow bidder B the opportunity to express its best and final offer. We can achieve this by allowing remaining bidders at the end of the clock stage to make best and final offers.

Threshold problems

A8.127 The downside of package bidding is that facilitating aggregation for larger bidders needs to be balanced against the so-called 'threshold problem'. This occurs where small bidders (wanting few lots) find it difficult to organise themselves into implicit coalitions capable of displacing larger bidders (wanting to aggregate many lots), even though their collective valuation may be higher. In a conventional SMRA, there may be a coordination problem in terms of which small bidder moves first to raise prices to displace a large bidder. In any auction with package bidding, the question is whether individual small bidders will have sufficient incentives to raise bids to levels where they collectively displace aggregating bidders.

A8.128 Consider a simple example in which individual bidders have reached the end of the clock auction, but have not yet bid sufficient to displace an aggregating bidder. Take again the example with 10 lots and suppose that:

- bidder A wants 10 lots at a maximum of £10 per lot;
- bidder B wants 3 lots at a maximum of £20 per lot; and
- bidder C wants 4 lots at a maximum of £15 per lot.

A8.129 Together, B and C are prepared to pay £120, so it is efficient for them to win rather than A. However, once the clock price gets to £10, A drops out. At a price of £10, the bids of B and C are only £70. Therefore, B and C will not win unless they make higher best and final offers after the end of the clock auction.

A8.130 This creates a prisoners' dilemma situation between bidders B and C. Each would like the other to raise its bid in order to beat A. If there was open bidding, then there might be an incentive for bidders B or C to drop out of the bidding below their true value, in the hope that the other bidder will bear the financial burden of beating bidder A. This creates the potential for an inefficient outcome in which B and/or C drop out below their true values and fail to win even through they have a higher aggregate value than bidder A. We can reduce the likelihood of such an outcome by having just a single round of bidding by B and C (i.e. their best and final offers). In this case, there is no subsequent opportunity for bidders B or C to pick up the burden of beating bidder A.

Complexity and strategic bidding

A8.131 If, as here, there are a large number of individual lots, then an SMRA with package bidding may become complex if we permit bids on every combination, owing to the enormous number of possible packages which bidders are confronted with. Even restricting packages to contiguous lots, there are many bids that can be made each round. In contrast, by using generic lots bidders need only state how many paired and unpaired lots they want at a given price. This dramatically simplifies the choices that bidders need to make.

A8.132 The clock stage is very straightforward for bidders. There are uniform prices for 5 MHz lots in the 2.6 GHz band and a second clock price for the 2010 MHz lot in each round, and bidders specify the number of paired and unpaired lots that they desire and whether they want the 2010 MHz lot at its prevailing price. As paired and unpaired lots are not significant substitutes, we do not need to allow switching across these two categories and so can specify activity rules for each category separately. However, we need to treat the 2010 MHz lot as being similar to unpaired 2.6 GHz lots for the purposes of activity requirements (subject to using an appropriate eligibility points weighting scheme) as it is likely to be a substitute for unpaired 2.6 GHz lots.

A8.133 The simplicity of this auction format for bidders controls the risk of strategic behaviour. There is little scope for using bid amounts for signalling, price manipulation (bidding up specific lots with the aim of disadvantaging competitors with less flexible bid strategies) or punishment (encouraging other bidders to withdraw demand for specific lots by threatening to drive up the price of other lots that they also want). There is a potential concern that the 2010 MHz lot could be used for parking (bidding on lots a bidder does not want to maintain eligibility, before switching to your actual target lots later) to facilitate strategic behaviour in bidding for unpaired lots. However, this opportunity is self-limiting due to the small size of the 2010 MHz lot in terms of eligibility points as compared with even the minimum amount of unpaired spectrum available.

Strategic demand reduction

A8.134 One possible concern with the clock auction approach is that it may encourage so-called strategic demand reduction. Specifically, bidders may be tempted to reduce demand in the clock stage in order to achieve a lower price per lot.

A8.135 Ofcom does not consider this risk to be significant:

- We can expect the auction itself to be competitive. This tends to reduce the incentive for strategic demand reduction if winners are unlikely to receive a large proportion of the available lots.

- Incentives for strategic demand reduction are largest for those wanting most lots, so this works towards producing less concentrated downstream markets for goods and services. Clearly this is only relevant where winners are likely to compete in the same economic markets, but this appears likely for this band. Although strategic demand reduction may be poor for efficiency in the narrow sense of allocation within the auction relative to the valuations of bidders, it may be good for efficiency in the wider sense of reducing any incentives to concentrate lots to gain downstream market power. Where bidders are downstream competitors, this makes the overall impact of strategic demand reduction on consumer welfare ambiguous.

- It is difficult to predict what the effect of reducing demand will be on price paid, as this is not determined solely by the outcome of the clock auction, but rather by optimising over all bids received in the course of the auction.

A8.136 There may be an opportunity to reduce incentives for strategic demand reduction by ending the clock stage before demand has been reduced to less than or equal supply, and then providing a greater role for best and final offers at the end of the clock stage in determining the final allocation.

Rules for the first stage

A8.137 The first stage of the auction is a combinatorial clock auction with two categories of generic lots in the 2.6 GHz band (paired and unpaired lots) and a single lot at 2010 MHz. Throughout the auction, bids are always made for packages of lots. These package bids stand or fall in their entirety. The use of generic lots in the 2.6 GHz band means that the number of package options is small. A package bid simply specifies:

- a number of paired lots in the 2.6 GHz band;
- a number of unpaired lots in the 2.6 GHz band; and
- whether the 2010 MHz lot is included or not.

A8.138 Bidding proceeds in multiple rounds and finishes simultaneously for all lots. In each round, we ask for each bidder's **most preferred package** of lots at given prices.[133] Further, in situations where a bidder's eligibility reduces, we ask for **best and final offers** on any packages on which the bidder will no longer be able to bid for in future rounds. The best and final offers are not considered until the best-and-final-offers stage.

A8.139 The statement of most preferred package by bidders is used to assess whether there is excess demand and to determine which prices need to be increased (and by how much). This avoids the complex winner determination and price setting step needed each round in a combinatorial auction.[134] Therefore, prices move through a clock mechanism. However, as bidders reach their valuations for certain packages of lots, we provide for them to state their demand for multiple packages, choosing the bid level for each to represent their relative preferences. Some restrictions are necessary on best and final offers to ensure that they are consistent with the clock auction.

Activity rules

A8.140 We propose **two separate activity rules**, one relating to the unpaired lots at 2.6 GHz and the 2010 MHz lot, and the other to the paired lots at 2.6 GHz. These activity rules apply independently and there is no link between them. This approach assumes that bidders will not be treating paired and unpaired lots as substitutes, so that activity requirements can be applied independently.

A8.141 We start with the simpler case of the paired lots:

[133] Unlike a conventional SMRA, there is no concept of standing highest bidders at the end of each round.

[134] In the general case, there may be no prices for each lot such that winning package bids exceed the sum of prices of their constituent lots and losing package bids are exceeded by the sum of prices of their constituent lots. This causes difficulties in setting lot prices for the next round in combinatorial SMRAs. Although various algorithmic approaches have been suggested to find lot prices that best approximate these conditions, we typically additionally require that lot prices are fairly similar (and possibly also non-decreasing) from one round to the next.

- At the start of the auction, bidders have an initial eligibility to bid for paired lots (which we call **paired eligibility**) determined by their application form and associated with their deposit;
- paired eligibility at the start of a round would be equal to the number of bids for paired lots made in the previous round;
- The number of paired bids may not exceed the paired eligibility.

A8.142 These rules have the effect that a bidder cannot bid for more paired lots than it bid for in the last round. Also, a bidder can never bid on more paired lots than its initial paired eligibility.

A8.143 There is a separate calculation of **unpaired eligibility**, which is fungible between the 2.6 GHz unpaired lots and the 2010 MHz lot:

- each 5 MHz unpaired lot in the 2.6 GHz band is assigned one eligibility point;
- the 2010 MHz lot would count for two eligibility points, reflecting its status as an inferior substitute, but its larger size at 12.5 MHz.

A8.144 As with paired eligibility, initial unpaired eligibility is determined by the bidder's application and its associated deposit. Unpaired eligibility at the start of a round would be equal to activity on the unpaired lots at 2.6 GHz and the 2010 MHz lot in the previous round, using the points scheme above. Activity in the current round on unpaired lots and the 2010 MHz lot, calculated using the points scheme, may not exceed the unpaired eligibility.

A8.145 For the avoidance of doubt, paired and unpaired eligibilities are not fungible and are at all times independently computed. On application, bidders need to indicate their initial paired and unpaired eligibilities separately.

A8.146 Ideally, the points scheme for 2.6 GHz unpaired lots and the 2010 MHz lot should reflect their likely relative closing prices. This reduces the incentives for strategic behaviour such as 'parking' (i.e. preserving eligibility on lots that are relatively cheap as measured by their price per eligibility point, either to hide true intentions or to maintain eligibility to punish other bidders if tacit collusion breaks down). However, these closing prices can only be guessed. It is reasonable to suppose that the 2010 MHz lot is likely to be less valuable per MHz than the 2.6 GHz spectrum, implying that it should have a relative weight of less than three. However, given that there is only a single 2010 MHz lot, there is no benefit in setting its eligibility points weight at some fractional amount.[135] Therefore, the only choices are to set a relative weight of 2 or of unity (i.e. equal weight for both types of lots). Given that there is 12.5 MHz of spectrum in the 2010 MHz lot, a relative weight of 2 seems the most likely to reflect relative value.

A8.147 An alternative to setting fixed weights for the two categories of lots is to use a weighting scheme based on the previous rounds' relative prices (a so-called

[135] It is easy to check that setting a fractional relative weight, say 2.5, for the 2010 MHz lot is no different that setting the relative weight equal to the next lowest integer, in this case 2. Because there is only a single 2010 MHz lot, there is no way for a bidder to benefit from the fractional part of the eligibility weight in relaxing its activity requirement. Note also that this argument depends only on the *relative* weight; the example is exactly the same if 2.6 GHz lots had weight 2 and the 2010 MHz lot had weight 5.

revealed preference activity rule). Although this approach has some theoretical attractions, it does not add much in this case. There is still an integer issue even with a more complex rule: all that is relevant for the activity requirement in each round is the whole number of unpaired lots that can be bid on instead of bidding of the 2010 MHz lot. Therefore, this approach only yields a different activity requirement from the fixed weights approach in rounds where the ratio of the 2.6 GHz clock to the 2010 MHz clock moves outside the range 1:1 to 1:3.

A8.148 Given that there is just a single 2010 MHz lot, the opportunity for strategic ‘parking’ behaviour is fairly limited even if the relative eligibility weight between 2.6 GHz unpaired lots and the 2010 MHz lot is wrongly set. Therefore, we propose to adopt the simple approach of a using a fixed relative eligibility weighting of two.

Prices

A8.149 There are **two separate price clocks**:

- one clock for 5 MHz lots in the 2.6 GHz band (**the 2.6 GHz clock**); and
- the other for the single 2010 MHz lot (**the 2010 MHz clock**).

A8.150 Prices for paired and unpaired lots are determined by the 2.6 GHz clock price, with the price of paired lots typically twice that of unpaired lots. There are some limited exceptions to the 2:1 pricing ratio, as we discuss below.

A8.151 Initially, there is a uniform reserve price per 1x5 MHz lot in the 2.6 GHz band. Hence, if the reserve price for a 1x5 MHz lot is £50,000, then the reserve price for an unpaired lot would be £50,000 and the reserve price for a paired lot would be £100,000. There is also a reserve price for the 2010 MHz lot implied by its relative eligibility point weight (i.e. if the reserve price for a unpaired lots its £50,000 and the eligibility point weight for the 2010 MHz lot is two, then its reserve price is £100,000).

A8.152 Taking this approach, deposits could be set equal to the 5 MHz reserve price, multiplied by the sum of the initial unpaired eligibility and twice the initial paired eligibility. This is the total value at reserve prices of the maximum number of bids that can be made given initial eligibility.

A8.153 In subsequent rounds, prices of categories of lots in excess demand are set equal to the prices from the previous round plus a bid increment. This bid increment could either be a fixed amount, pre-announced by the auctioneer, or else could be varied according to the extent of excess demand. The second approach has the benefit that the auction may be quicker, as larger price increments can be applied when there is more excess demand. For example, the price increment could be a simple linear function of the number of lots of excess demand. We discuss how to measure excess demand later.

Making bids

A8.154 Bidders indicate their **most preferred combination** of paired, unpaired and 2010 MHz lots at a given price for a 5 MHz lot in the 2.6 GHz band and a given price for the 2010 MHz lot. The total number of bids made for each type of lot should not exceed the bidder’s relevant eligibility. In the event that there was no reduction in eligibility entailed by the bids made, this would be all the information provided by the bidder.

A8.155 In the case that the bids entailed a reduction in eligibility relative to the previous round for either category of lot, the bidder would have the option to enter **best and final offers**.[136] These best and final offers would only be possible on packages on which:

- bids cannot be made in subsequent rounds due to the reduction of eligibility implied by the bidder's choice of most preferred package, and
- on which bids would have been possible in the previous round.

A8.156 Best and final offers must be made at prices not exceeding the current price, so that they cannot be used instead of carrying on to the next round and so subvert the price discovery process.

A8.157 Three simple examples make this clear. Suppose that in round *N*, the price of a 5 MHz lot was 10 and the bidder made bids for 6 paired lots and 4 unpaired lots. No bid was made on the 2010 MHz lot, so paired eligibility is 6 and unpaired eligibility is 4. Suppose that the price of a 5 MHz lot in round *N*+1 increased to 12. Then consider three cases according to the bid made in round *N*+1:

i) the bidder continues to bid on 6 paired lots and 4 unpaired lots;

ii) the bidder reduces its demand to 5 paired lots, but maintains demand for 4 unpaired lots;

iii) the bidder reduces its demand to 5 paired lots and 2 unpaired lots.

A8.158 In the first case, eligibility is maintained at the previous level, so there are no best and final offers that can be made.

A8.159 In the second case, paired eligibility falls and the bidder will not be able to bid again for 6 paired lots. The bidder may enter a best and final offer for 6 paired lots at a price not exceeding this round's price of 12. For example, the bidder might have a maximum willingness to pay of 11 per lot, so would enter this as its best and final offer for 6 paired lots. This could be a package bid with up to 4 unpaired lots as we allow best and final offers to be package bids.

A8.160 In the third case, there is a reduction in both paired and unpaired eligibility. We would allow best and final offers not exceeding 12 for all those packages that the bidder would have been eligible to bid on in round *N*, but will be unable to bid on from round *N*+2 onwards, i.e.:

- 6 paired lots, as a package bid with up to 4 unpaired lots (or 2010 MHz instead of two of these unpaired lots);

[136] It would be possible to defer the entry of best and final bids until the end of the clock stage of the auction. Bids would still be subject to the same conditions as described above in the main text. This might have the advantage that bidders could make use of any further information that they glean in the course of the open auction. However, to avoid undermining incentives for truthful bidding in the open auction, these last and final bids would need to be capped at the level of prices in the relevant round where eligibility was dropped. This would seem to limit any benefit that could be achieved from delaying the best and final bids until the end. Also, entering best and final bids in the round when eligibility is dropped is an intuitively obvious process for bidders, whereas leaving all the best and final bids until the end would require complex data entry by bidders. However, it would only be necessary to enter this information in situations in which there would otherwise be unsold lots.

- 4 or 3 paired lots (or 2010 MHz instead of two paired lots) with up to 6 unpaired lots as a package bid.

A8.161 It is not onerous to enumerate the packages that can be bid on in round *N*, but which cannot be bid on in round *N*+2. Providing the reduction is eligibility is modest, there will be a small number of such packages. Only where there is a large drop in eligibility will there be a significant number of packages for the bidder to consider. However, it may well be that large drops in eligibility are associated with bidders exiting the auction entirely (say they need a certain minimum number of lots). Bidders may not necessarily want to make use of all the available best and final offers available to them if some relate to packages that are too small to offer viable services.

A8.162 Bidders are under no obligation to make use of best and final offers. However, in the event that there are otherwise unallocated lots, they can improve their chances of winning additional lots through making best and final offers.

A8.163 Best and final bids are not relevant for the purposes of calculating eligibility in the subsequent rounds of the clock stage; only the most preferred bid is considered.

Waivers

A8.164 Waivers can be played instead of entering a bid. By playing a waiver, bidders avoid losing eligibility if they fail to enter a bid; both paired and unpaired eligibility will be maintained in the following round.

A8.165 Bidders start the auction with **two waivers**. Additional waivers may be granted to all bidders at the discretion of the auctioneer. Waivers can be deployed in any round *except* round 1. Waivers would be played automatically by the bidding system if a bidder failed to submit a bid decision subject to these limitations.

A8.166 The clock stage will not finish after a round in which at least one waiver was played. In the event that there was excess demand in the previous round, prices will be increased as previously described. If there was no excess demand for any category of lots, prices remain the same and the clock stage continues.

End of the clock stage

A8.167 At the end of each round, the auctioneer determines whether there is excess demand for paired and unpaired lots and the 2010 MHz lot given the most preferred packages stated by bidders. If there is no excess demand, the clock stage stops. The conditions for absence of excess demand are somewhat complicated by the supply of lots at 2.6 GHz depending on the number of guard blocks that need to be withdrawn. These conditions are discussed below.

A8.168 Once the clock stage stops, those remaining bidders with eligibility to bid may make best and final offers on those packages on which they are still eligible to bid. There are no restrictions on the levels of these bids.

A8.169 Winning bids for generic lots are then determined. These are the set of bids of greatest total value amongst all those bids made (including both most preferred packages and best and final offers), subject to:

- no more lots being awarded than are available (i.e. no excess demand);

- at most one bid being accepted from each bidder.

Winning prices

A8.170 Winning prices for the first stage are determined using a **second price rule**. These are prices such that:

- there is no dissatisfied bidder or coalition of bidders able to suggest an alternative outcome (in terms of prices paid and lots received) preferred by all members of the coalition and leaving the seller no worse off;
- these are the lowest such prices subject to revenue being at least as great as the outcome of the clock auction.

A8.171 This corresponds to a notion of competitive pricing, in that winners have paid sufficient such that losers cannot suggest an alternative that does not make the seller worse off.

A8.172 Typically, there are many possible prices satisfying these conditions. Amongst all these possible prices, those closest to the clock auction outcome would be selected.

A8.173 The advantage of this pricing rule over a simpler ‘pay what you bid’ rule is that it substantially reduces the incentives for the remaining bidders at the end of the clock stage to shade their bids, submitting bids significantly below their valuations. The amount that winning bidders will ultimately pay is determined primarily by the bids of competitors, so there are good incentives to make bids close to the value that bidders place on packages.

Transparency

A8.174 At the end of each round of the clock stage, the auctioneer would announce the level of excess demand for 2.6 GHz lots and the 2010 MHz lot. There are two options with regard to releasing additional information:

- releasing all clock bids on an anonymous basis (i.e. the packages bid on and amounts of the bids, but not who made them);
- full transparency of all clock bids.

A8.175 Ofcom considers that there is a case for at least releasing all clock bids on an anonymous basis to reduce common value uncertainty. The pros and cons of additionally having full transparency seem difficult to judge. Full transparency would provide somewhat richer information for bidders to benchmark their valuations against the behaviour of other bidders, and so further reduce common value uncertainty. However, much of this benefit would already have been obtained by releasing these bids on an anonymous basis. Against this, full transparency might facilitate collusive behaviour.

A8.176 Releasing information about best and final offers each round is potentially useful. Not only might this reduce common value uncertainty, but it also facilitates bidding by implicit coalitions of smaller bidders who are trying to defeat other bidders who are aggregating lots, possibly reducing threshold problems. At the very least, it is useful to release the packages bid on in best and final offers on an anonymous basis. There is less reason to release the value of bids, as these can in any case be fairly closely inferred from the round prices. If bid amounts were released, they would need to be rounded off to frustrate code bidding.

Conditions for no excess demand

A8.177 We now explain what conditions need to be satisfied for there to be no excess demand at a certain price. For the 2010 MHz lot, this is simply a matter of seeing if there was more than one bid made for it.

A8.178 Comparing supply and demand for the 2.6 GHz band is complicated by the fact that we cannot take the supply of lots in the 2.6 GHz band as fixed. If there is a split award an additional lot needs to be withdrawn as a guard band. However, whether a split award is necessary itself depends on whether demands for unpaired spectrum can be packed into the upper and lower unpaired areas.

A8.179 Introduce the following notation:

- Let P be the total demand for paired lots (expressed in 5 MHz blocks, so twice the number of paired bids);
- Let u_n be the number of unpaired lots demanded by bidder n;
- Let $U=\sum_n u_n$ be the total demand for unpaired lots.

A8.180 If U unpaired lots are to be allocated, let $L(U)$ and $M(U)$ be the number of lots available in the lower and upper unpaired areas respectively.[137] Table 1 I lists the values of $L(U)$ and $M(U)$ for each possible value of U. By definition,

$$L(U) + M(U) = U.$$

A8.181 There is no excess demand under the following conditions, **all of which must be true**:

- $P \leq 28$ (so there is no more demand for paired lots than the maximum available)
- if $P = 0$, then $U \leq 38$ (as if all paired lots are broken down, there are 38 unpaired lots);
- if $P > 0$, then $P + U \leq 37$ (even with a split award, demand of 36 lots can always be accommodated and demand of 37 can be accommodated if there is not a split award);
- if $P > 0$ and $P + U = 37$, then unpaired spectrum can be awarded without a split, so there must be a set, S, of bidders for unpaired lots whose demands pack into the upper unpaired area, i.e. $\sum_{n \in S} u_n = M(U)$.

A8.182 If there is excess demand, then the clock auction continues. The clock price is increased by an increment determined by the auctioneer. This could be a function of excess demand. Excess demand, Z, for 2.6 GHz lots is defined in cases where the auction does not terminate as:

- if $P = 0$, then $Z = U - 38$

[137] $M(U)$ refers to the maximum number of unpaired lots in the upper unpaired area (not the number available if an extra guard band were required for a split allocation, which would be $M(U) - 1$).

- if $P > 0$ and $P + U \geq 37$, then Z = max($P + U – 37$, $P - 28$)
- if $P > 0$, $P \leq 28$ and $P + U = 37$, then $Z = 1$ when paired spectrum cannot be awarded without a split.

Unpaired lots closing first

A8.183 If at any point in the clock stage, aggregate demand for unpaired lots drops to nine or less whilst there is still excess demand for paired lots, then there would be no efficiency benefit in increasing the price of unpaired lots, as it is not possible to increase the supply of paired lots further by reducing demand for unpaired lots. We would already be at the minimum number of unpaired lots that can be allocated.

A8.184 In any round where total demand for unpaired lots is less than or equal to nine, then the price of unpaired lots will be not be increased in that round and would be uncoupled from the 2.6 GHz clock price. The price of unpaired lots would be frozen at this level whilst the 2.6 GHz clock price increased. The price of paired lots will remain equal to twice the 2.6 GHz clock price and so may rise to levels more than twice that of the unpaired lots.

A8.185 It is still possible that continuing competition for the 2010 MHz lot could lead to some bidders switching back to the unpaired lots as the price of the 2010 MHz lot rose. In this case, there are two possible options for dealing with any subsequent round in which demand for unpaired lots then increased to strictly more than nine:

- The price of unpaired lots could immediately revert to the 2.6 GHz clock price applying in that round. Clearly this could lead to unpaired demand dropping to strictly less than nine at the higher price. However, bidders would be able to indicate their maximum willingness to pay for unpaired lots through best and final offers, which would determine which bidders received the available nine unpaired lots;
- Alternatively, a “sub-auction” could be run, in which the price of unpaired lots were increased round by round until either demand dropped to nine or else the 2.6 GHz clock price was reached. The 2.6 GHz and 2010 MHz clocks would remain frozen until this process was concluded.

A8.186 These proposals differ only in the information available to bidders for unpaired lots in determining the maximum amount they are willing to pay. Given that this case is not particularly likely, the first approach may be preferable as it is much simpler and maintains the pace of the auction.

When is the first stage needed?

A8.187 As we have discussed, paired eligibility is fungible across the 2.6 GHz unpaired lots and the 2010 MHz lot. Even if initial unpaired eligibility were less than 11 in total across all bidders (i.e. the minimum number of nine unpaired lots with one eligibility point each plus two points for the 2010 MHz lot), there would still be a question about which bidders got 2.6 GHz spectrum and which got the 2010 MHz lot. In particular, it is still possible that there could be competition for the 2010 MHz lot (if total initial unpaired eligibility across bidders is strictly greater than one) or for the 2.6 GHz unpaired lots (if total initial unpaired eligibility exceeds nine). Therefore, it is generally necessary to run the combinatorial clock auction rather than moving directly to the assignment stage. However, the combinatorial clock auction might finish with no increase in the price for 2.6 GHz lots or the 2010 MHz lot if it turns out there is no excess demand once bidders have indicated their preferences in the first round.

Key issues for the assignment stage

A8.188 The assignment stage is intended to turn the outcome of the first stage (in terms of the number of generic lots won by bidders) into an allocation of specific frequencies in the 2.6 GHz band. Winners of the first stage participate in a one-shot sealed bid process.

A8.189 This sealed-bid auction allows bidders to pay a premium over and above their payment for generic lots as determined by the first stage in order to compete for more desirable assignments. However, there is no obligation on bidders to make such top-up bids. Bidders are guaranteed to receive an assignment compatible with the generic lots won in the first stage even if they do not make such top-up bids.

Fragmentation of potential outcomes

A8.190 The structure of the first stage of the auction is such that the outcomes it produces are always consistent with there being at least one way to award contiguous spectrum, subject to at most one bidder receiving a split award of unpaired spectrum. Therefore, we can restrict the second stage to produce only outcomes with these contiguity properties.

A8.191 This is easy to see for the case of paired spectrum, as we could award contiguous frequencies to bidders according to the number of generic lots won by starting from the lowest frequency block and working up. Indeed, there will be various ways of doing this, which we can enumerate by permuting the locations of the bidders within the band.[138]

A8.192 The situation with the unpaired spectrum is similar, though we need to distinguish whether or not there is a split award:

- If the first stage of the auction stops with total demand for paired and unpaired lots of 37 blocks of 5 MHz, by construction of the conditions for termination of first stage, there must be at least one way of awarding the unpaired spectrum without needing a split award. Therefore, the logic is the same as with the paired spectrum; the clock outcome can be implemented with contiguous spectrum being granted to bidders. All possible ways of doing this can be generated by permuting the bidders.

- If, alternatively, the first stage of the auction terminated with total demand strictly less than 37 blocks, then it may not be possible to assign the unpaired lots without creating a split award. The conditions for termination of the first stage provide for withdrawal of an additional guard band in the case that a split award cannot be avoided. All possible ways of doing this can be generated by first permuting the bidders and then additionally considering that the split award need not necessarily be at the top of the lower unpaired area and the bottom of the upper unpaired area.

[138] Imagine 'slicing' off the requisite number of lots to give to each bidder as if cutting up a salami sausage. The number of allocations is just the number of permutations of the winning bidders. This is very much less than the number of permutations of the lots. For example, with five winners there are just 120 permutations of the winners. Therefore, running the first stage produces a massive reduction in the complexity of the allocation problem at hand.

A8.193 Where a split award occurs, then the bidder affected by the split will receive two or more blocks in the lower unpaired area. This is because if there was a split award in which the split bidder received a single block in the lower unpaired area, then we could give them the guard block lot at the bottom of the upper unpaired area instead, and so achieve an allocation in which no bidder needs to have their unpaired demand split. Therefore, this situation could not be one where a split award was necessary.

A8.194 It is entirely possible that the bidder subject to the split award will receive a single lot in the upper unpaired area. However, this lot will be fully usable, as the immediately lower lot will have been reserved as a guard block in the case of a split award. Therefore, receiving one lot in the upper unpaired area under a split award should be no less useful than receiving two lots in the lower unpaired area.

Assigning guard band lots or unsold lots

A8.195 The assignment stage can also be used to assign the one or two guard blocks that are not awarded in the first stage. These would be subject to significantly curtailed usage rights.

A8.196 The simplest approach would be to award guard blocks directly to adjacent users, on the basis that:

- this would provide them with greater certainty over their ability to manage interference; and
- they may be best able to use the lots, perhaps on a geographic basis, as a result of negotiation with their neighbour.

A8.197 However, in this case, Ofcom would need to decide who should receive the lots:

- In the case that there is a bidder that has a split award of unpaired lots, there is a case to award that bidder the additional guard block that is created adjacent to their spectrum, as this would ensure that they always had at least two contiguous lots in the upper unpaired area. This would partially offset any detrimental effect of receiving spectrum in two contiguous blocks rather than one.
- Lot 38 is adjacent to only one user in this band. Lot 38 is available when final demand for paired spectrum is 13 lots, in which case lot 38 is adjacent to a paired lot winner of blocks 13 and 37. It is not clear that this paired lot winner would have much use for lot 38, but there would be no other natural candidate.
- Lot 24 would be adjacent to one paired and one unpaired use; there is no reason why either party should be preferred in receiving this lot.

A8.198 Where there is a choice of adjacent winner (i.e. lot 24 and possibly the additional guard block in the event of a split award if this were not gifted to the bidder subject to the split award) it would be possible to resolve this through bidding for packages including adjacent guard blocks in the assignment stage. This is the approach we describe below.

A8.199 Alternatively, it would be possible to offer the guard blocks more widely than to just the neighbouring users. This might be appropriate if there are restricted uses of the guard block that do not interfere with neighbouring users. In this case, the assignment stage would additionally need to offer all packages of frequencies with and without the various guard blocks. This approach is somewhat more complex due to the greater number of packages of lots available in the assignment stage and may not offer any significant benefits in terms of spectrum use.

Rules for the assignment stage

A8.200 We now describe the detailed rules for the assignment stage. We can ignore the single 2010 MHz lot as this will have been allocated to a unique winner at the end of the first stage.

Feasible bids in the second stage

A8.201 The first step is to identify all the feasible ways of awarding specific frequencies that are consistent with the outcome of the first stage of the auction.

A8.202 For each paired lot winner, we identify an exhaustive list of packages of contiguous lots which are consistent with the number of blocks that they won in the first stage, and which may allow all other winners of paired lots to receive contiguous assignments. There will be a relatively small number of such packages given the requirement for contiguity.

A8.203 For each unpaired lot winner, we also identify an exhaustive list of packages of lots for potential assignments, subject to the following conditions:

- If it is possible to assign packages in a way that all bidders would receive contiguous lots, then only these packages are considered; and
- If this is not possible, then only packages where no more than one bidder would receive a split assignment will be considered.

A8.204 If any of these packages are adjacent to a guard block, an *additional* package is created that combines that assignment with the guard block. The exact number of packages presented to each bidder will depend on the case at hand, particularly on the total number of bidders. The number of ways of assigning frequencies contiguously is related to the number of permutations of winning bidders, rather than the number of permutations of lots, so should be a manageable number.

Commitments carried over from the first stage

A8.205 Winning a certain number of generic lots in the first stage at a certain price entails a commitment to purchase all relevant packages of specific frequencies in the assignment stage at that price. For example, winning 3 paired lots and 4 unpaired lots in the first stage at a total price of 10 would mean this bidder is considered as making a bid for every feasible package of 3 specific paired frequencies and 4 specific unpaired frequencies in the assignment stage at a price of 10.

A8.206 There would be a commitment to any additional packages that included unsold lots or guard bands as well. However, the minimum bid would be same as the corresponding package without unsold lots or guard bands.

Making bids

A8.207 Bidders would be able to raise their bids for specific packages of lots above the floor set by the prices determined by the clock stage. They would do this by means of a top-up bid made for specific frequencies. Bidders would be under no obligation to make top-up bids. These bids would be for packages of lots so there would be no aggregation risks.

Winner determination

A8.208 The final outcome is achieved by optimising over the feasible assignments and finding the assignment with the greatest total value of accepted top-up bids, subject to all bidders receiving the same number of lots that they won in the first stage. A further constraint on the optimisation is that, unless a split award is necessary, all bidders must receive contiguous assignments of paired spectrum and contiguous assignments of unpaired spectrum. If a split award is necessary, at most one bidder can receive a split assignment of unpaired spectrum.

Tie-breaking

A8.209 It is quite likely that many bidders will not raise their bids in the assignment stage if they are indifferent amongst which specific lots they receive. Given that bidders will often be bidding the same amount per lot – certainly the case for those bidding in the last round of the clock auction – this makes some ties likely. In the event of ties, a random process would be used to pick one of the tied optimal allocations.

Payments

A8.210 The winning of a specific frequency block would pay the relevant price for a generic lot determined in the first stage of the auction, plus any top-up bid made in the second stage.

Annex 9

Draft licence template

A9.1 Please note that the following template licence and schedule represents Ofcom's current thinking and may well change as Ofcom's thinking develops and after consideration of responses to this consultation

A9.2 The references in this template licence and schedule to the various Acts that will be replaced by the Wireless Telegraphy Act 2006 (2006 Act) will be updated when the 2006 Act comes into force.

A9.3 All figures provided in this licence and schedule are indicative only and subject to the present consultation.

A9.4 The following draft licence is an illustration for paired FDD use in the 2.6 GHz band.

DRAFT LICENCE

Please note that the following template licence and schedule represents Ofcom's current thinking and may well change as Ofcom's thinking develops and after consideration of responses to this consultation

The references in this template licence and schedule to the various Acts that will be replaced by the Wireless Telegraphy Act 2006 (2006 Act) will be updated when the 2006 Act comes into force.

All figures provided in this licence and schedule are indicative only.

Wireless Telegraphy Acts 1949 and 1998

Office of Communications (Ofcom)

SPECTRUM ACCESS LICENCE 2.6 GHz Band

Licence no: **[xxxxxx]**

Date: **[date]**

1. The Office of Communications (Ofcom) grants this licence (the "Licence") to

[company name]
Company Reg No: [xxxxxxxx]
(the "Licensee")
[address 1]
[address 2]
[address 3]
[postcode]

to establish, install and use radio transmitting and receiving stations and/or radio apparatus as described in the Schedule (the "Radio Equipment") subject to the terms, set out below.

Licence Term

2. This Licence shall continue in force until revoked by Ofcom in accordance with paragraph 3 below or surrendered by the Licensee.

Licence Variation and Revocation

3. Pursuant to section 4 of the Wireless Telegraphy Act 1998, Ofcom may not revoke this Licence under section 1(4) of the Wireless Telegraphy Act 1949 except:

(a) at the request of, or with the consent of, the Licensee;

(b) in accordance with paragraph 8 of this Licence;

(c) if there has been a breach of a term of the Licence;

(d) if, in connection with the transfer or proposed transfer of rights and obligations arising by virtue of the Licence, there has been a breach of any provision of Regulations made by Ofcom under the powers conferred by section 168(1) and (3) of the Communications Act 2003[1];

(e) if, in relation to the Licensee, any of the events listed in regulation [***reference to the activity rules contained in the auction regulations to be included***] occurred prior to the grant of this Licence where the occurrence of the event materially affected the outcome of the award process under those Regulations;

(f) in accordance with section 4(5) of the Wireless Telegraphy Act 1998;

(g) if it appears to Ofcom to be necessary or expedient to revoke the Licence for the purposes of complying with a direction by the Secretary of State given to Ofcom under section 5 or section 156 of the Communications Act 2003; or

(h) for reasons related to the management of the radio spectrum, provided that in such case:

(i) this power to revoke may only be exercised after at least five (5) year's notice is given in writing to the Licensee; and

(ii) such notice must expire after fifteen (15) years from the date of this Licence.

4. Ofcom may only revoke or vary this Licence by notification in writing to the Licensee and in accordance with section 1E of the Wireless Telegraphy Act 1949.

Changes

5. This Licence is not transferable. The transfer of rights and obligations arising by virtue of this Licence may however be authorised in accordance with

[1] These are regulations on spectrum trading.

regulations made by Ofcom under powers conferred by section 168(1) and (3) of the Communications Act 2003[2].

6. The Licensee must give prior notice to Ofcom in writing of any proposed change to the Licensee's name and address from that recorded in the Licence.

Fees

7. The licence fee in respect of this Licence is **[£xxxxxx]**, which for the avoidance of doubt is exclusive of any VAT which may ultimately be payable.

8. On or after the expiry of twenty (20) years from the date this Licence was granted, the Licensee shall pay to Ofcom such sum(s) as may be provided for in Regulations made by Ofcom under sections 1 and 2(2) of the Wireless Telegraphy Act 1998, failing which Ofcom may revoke this Licence.

9. The Licensee shall also pay interest to Ofcom on any amount which is due under the terms of this Licence or provided for in any Regulations made by Ofcom under sections 1 and 2(2) of the Wireless Telegraphy Act 1998 from the date such amount falls due until the date of payment, calculated with reference to the Bank of England base rate from time to time. In accordance with section 4A of the Wireless Telegraphy Act 1998 any such amount and any such interest is recoverable by Ofcom.

10. If the Licence is surrendered or revoked, no refund, whether in whole or in part of any amount which is due under the terms of this Licence or provided for in any Regulations made by Ofcom under sections 1 and 2(2) of the Wireless Telegraphy Act 1998 will be made, except at the absolute discretion of Ofcom (in accordance with regulation 32 of the Wireless Telegraphy (Licence Award) (No. 2) Regulations 2006).

Radio Equipment Use

11. The Licensee must ensure that the Radio Equipment is established, installed and used only in accordance with the provisions specified in Schedule 1 of this Licence. Any proposal to amend any detail specified in Schedule 1 of this Licence must be agreed with Ofcom in advance and implemented only after this Licence has been varied or reissued accordingly.

12. The Licensee must ensure that the Radio Equipment is operated in compliance with the terms of this Licence and is used only by persons who have been authorised in writing by the Licensee to do so and that such persons are made aware of, and of the requirement to comply with, the terms of this Licence.

Access and Inspection

13. The Licensee shall permit a person authorised by Ofcom:

(a) to have access to the Radio Equipment; and

[2] See Ofcom's website for the latest position on spectrum trading and the types of trade which are permitted.

(b) to inspect this Licence and to inspect, examine and test the Radio Equipment,

at any and all reasonable times or, when in the opinion of that person an urgent situation exists, at any time to ensure the Radio Equipment is being used in accordance with the terms of this Licence.

Modification, Restriction and Closedown

14. A person authorised by Ofcom may require any of the radio stations or radio apparatus that comprise the Radio Equipment to be modified or restricted in use, or temporarily or permanently closed down immediately if in the opinion of the person authorised by Ofcom:

(a) a breach of a term of the Licence has occurred; and/or

(b) the use of the Radio Equipment is causing or contributing to undue interference to the use of other authorised radio equipment.

15. Ofcom may require any of the radio stations or radio apparatus that comprise the Radio Equipment to be modified or restricted in use, or temporarily closed down either immediately or on the expiry of such period as may be specified in the event of a national or local state of emergency being declared. Ofcom may only exercise this power after a written notice is served on the Licensee or a general notice applicable to holders of a named class of Licence is published.

Geographical Boundaries

16. This Licence authorises the Licensee to establish, install and use the Radio Equipment only in the United Kingdom.

Interpretation

17. In this Licence:

(a) the establishment, installation and use of the Radio Equipment shall be interpreted as establishment and use of stations and installation and use of apparatus for wireless telegraphy as specified in section 1 of the Wireless Telegraphy Act 1949; and

(b) the expressions "undue interference", “station for wireless telegraphy” and “apparatus for wireless telegraphy” shall be construed in accordance with section 19 of the Wireless Telegraphy Act 1949.

18. The schedules to this Licence form part of this Licence together with any subsequent schedules which Ofcom may issue as a variation to this Licence at a later date.

19. The Interpretation Act 1978 shall apply to this Licence as it applies to an Act of Parliament.

Issued by Ofcom

Signed by

For the Office of Communications

DRAFT LICENCE

Please note that the following template licence and schedule represents Ofcom's current thinking and may well change as Ofcom's thinking develops and after consideration of responses to this consultation

All figures provided in this licence and schedule are indicative only.

SCHEDULE 1 TO LICENCE NUMBER: **[xxxxxx]**

Schedule Date: **[date]**

Licence Category: **Spectrum Access Licence 2.6 GHz Band**

1. **Description of Radio Equipment Licensed**

In this Licence, the Radio Equipment means any radio transmitting and receiving stations and/or any radio apparatus.

2. **Interface Requirements for the Radio Equipment use**

Use of the radio equipment shall be in accordance with the following Interface Requirement:

IR [xxxx] [3]for "Spectrum Access in the 2.6 GHz band".

3. **Special Conditions relating to the Operation of the Radio Equipment**

(a) During the period that this Licence remains in force and for six (6) months thereafter, unless consent has otherwise been given by Ofcom, the Licensee shall compile and maintain accurate written records of:

(i) the following details relating to the Radio Equipment:

a) postal address;

b) National Grid Reference (to one hundred (100) metres resolution);

[3] Available from the Ofcom website at http://www.ofcom.org.uk

c) antenna height (above ground level) and type, bearing east of true north; and

d) radio frequencies used by the Radio Equipment; and

(ii) a statement of the number of subscribing customers;

and the Licensee must produce these records if requested by a person authorised by Ofcom.

(b) The Licensee shall inform Ofcom of the address of the premises at which this Licence and the information detailed at sub-paragraph 3(a) above shall be kept.

(c) The Licensee must submit to Ofcom copies of the records detailed in sub-paragraph 3(a) above at such intervals as Ofcom shall notify to the Licensee.

(d) The Licensee must also submit to Ofcom in such manner and at such times, all information relating to the establishment, installation or use of the Radio Equipment, whether stored in hard copy or electronic form, as reasonably requested for the purposes of verifying compliance with this Licence or for statistical purposes.

(e) The Licensee must ensure that the Radio Equipment is established and installed only for terrestrial use.

4. Site Clearance Requirements

(a) Except where specified in sub-paragraph 4(b), the Licensee must obtain from Ofcom a valid site clearance certificate prior to establishing, installing or using the Radio Equipment:

(b) Sub-paragraph 4(a) does not apply to:

(i) base transceiver stations incorporating transmitters radiating not more than 17dBW ERP; and/or

(ii) aerial systems, which do not extend beyond thirty (30) metres above ground level, or which do not increase the height of an existing building by more than five (5) metres (whichever is the higher).

5. Cross-border coordination

The Licensee must ensure that the Radio Equipment is operated in compliance with such cross-border coordination and sharing procedures as may be notified to the Licensee by Ofcom.

6. Permitted Frequency Bands

Subject to the Out-of-Block Emissions permitted under paragraph 9, the Radio Equipment must only transmit and/or receive on the following frequency bands (the "Permitted Frequency Bands"):

(i) 2520 MHz - 2540 MHz Mobile Transmit

(ii) 2640 MHz - 2660 MHz Base Transmit

7. Maximum permissible EIRP

The maximum mean EIRP power in the Permitted Frequency Band(s) specified in paragraph 6(i) shall be 24 dBm/MHz.

The maximum mean EIRP power in the Permitted Frequency Band(s) shown in paragraph 6(ii) shall be 54 dBm/MHz.

8. Permissible Out-of -Block Emissions

For mobile station out-of-block emissions outside the Permitted Frequency Band(s) specified in paragraph 6(i), the maximum mean EIRP shall not exceed the following:

Offset from relevant block edge	Maximum mean EIRP
–10.0 to –6.0 MHz (lower edge)	–19 dBm/MHz
–6.0 to –5.0 MHz (lower edge)	$-9 + 10(\Delta_F + 5.0)$ dBm/MHz
–5.0 to –1.0 MHz (lower edge)	$-5 + (\Delta_F + 1.0)$ dBm/MHz
–1.0 to 0.0 MHz (lower edge)	$-5 + 15(\Delta_F)$ dBm/30kHz
0.0 to +1.0 MHz (upper edge)	$-5 - 15(\Delta_F)$ dBm/30kHz
+1.0 to +5.0 MHz (upper edge)	$-5 - (\Delta_F - 1.0)$ dBm/MHz
+5.0 to +6.0 MHz (upper edge)	$-9 - 10(\Delta_F - 5.0)$ dBm/MHz
+6.0 to +10.0 MHz (upper edge)	–19 dBm/MHz

Where: Δ_F is the frequency offset from the relevant block edge (in MHz)
The lower block edge being 2520 MHz
The upper block edge being 2540 MHz

For base station out-of-block emissions outside the Permitted Frequency Band(s) specified in paragraph 6(ii), the maximum mean EIRP shall not exceed the following:

Offset from relevant block edge	Maximum mean EIRP
–10.0 to –5.0 MHz (lower edge)	+4 dBm/MHz
–5.0 to –1.0 MHz (lower edge)	+4 dBm/MHz
–1.0 to –0.2 MHz (lower edge)	$+3 + 15(\Delta_F + 0.2)$ dBm/30kHz

–0.2 to 0.0 MHz (lower edge)	+3 dBm/30kHz
0.0 to +0.2 MHz (upper edge)	+3 dBm/30kHz
+0.2 to +1.0 MHz (upper edge)	$+3 – 15(\Delta_F – 0.2)$ dBm/30kHz
+1.0 to +5.0 MHz (upper edge)	+4 dBm/MHz
+5.0 to +10.0 MHz (upper edge)	+4 dBm/MHz

Where: Δ_F is the frequency offset from the relevant block edge (in MHz)
The lower block edge being 2640 MHz
The upper block edge being 2660 MHz

9. Interpretation

In this Schedule:

(a) "EIRP" means the equivalent isotropically radiated power. This is the product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna (absolute or isotropic gain);

(b) “ERP” means the effective radiated power. This is the power fed to the antenna multiplied by the maximum gain of the antenna with respect to a half-wave dipole.

(c) “dBm” means the power level in decibels (logarithmic scale) referenced against 1 milliWatt (i.e. a value of 0 dBm is 1mW);

(d) “dBW” means the power level in decibels (logarithmic scale) referenced against 1 Watt (i.e. a value of 0 dBw is 1 W).

(e) “Out-of-Block Emissions” means radio frequency emissions generated by the Radio Equipment and radiated into the frequency bands adjacent (in terms of frequency) to the Licensee’s Permitted Frequency Bands.

(f) “Base station” means a radio transmitter with or without a receiver installed to provide a communications service, typically used in mobile or broadcasting radio systems.

Annex 10

Other relevant regulation

A10.1 It is the responsibility of parties interested in using the available spectrum bands to provide electronic communications to identify what regulation may be relevant to the services that they envisage. This is true for all other aspects of regulation, such as broadcasting regulation and competition law.

A10.2 This Annex presents a brief introduction to some aspects of the regulatory framework for the electronic communications and broadcasting sectors that may be relevant to licensees using the 2.6 GHz, 2010 MHz and 2290 MHz bands, other than conditions relating to wireless telegraphy. Interested parties should seek their own legal advice as appropriate.

A10.3 As part of its regular reviews of regulatory packages, the European Commission, through the Information Society Directorate-General, has plans to assess the need to update and amend the current framework applicable to Electronic Communications. The relevant Directives include the Framework Directive (2002/21/EC), the Access and Interconnection Directive (2002/19/EC), the Authorisation Directive (2002/20/EC), the Universal Service Directive (2002/22/EC), the Privacy and Electronic Communications Directive (2002/58/EC), the relevant Competition Directive (2002/77/EC) and the Radio Spectrum Decision (676/2002/EC). As discussed in section 3, the review by the EC in cooperation with member states could lead to regulatory proposals from the second half of 2007 onwards. The proposals could result in changes to legislation applicable in the UK. Further information can be obtained from the EC and their website at www.europa.eu.int/information_society/activities/index_en.htm.

Conditions of entitlement

General Conditions of entitlement

A10.4 All providers of Electronic Communications Services (ECS) and Electronic Communications Networks (ECN) in the UK are covered by the General Conditions of Entitlement. Some apply to particular categories of ECS or ECN providers, mainly depending on whether they provide public services or networks and whether they provide publicly available telephone services or public telephone networks.

A10.5 It is the responsibility of any undertaking involved in the provision of ECS or ECN to identify which conditions apply to them and to ensure that it complies with them. Further information can be found at http://www.ofcom.org.uk/telecoms/ioi/g_a_regime/gce/gcoe/?a=87101 and the General conditions of entitlement published by Oftel in July 2003 can be found at http://www.ofcom.org.uk/static/archive/oftel/publications/eu_directives/2003/cond_final0703.pdf. It should be noted that from time to time Ofcom consults on changing the General Conditions of Entitlement. Some conditions have as a result been amended since the 2003 publication by Oftel. The corresponding regulatory statements and consultation proposals can be found on Ofcom's website. Ofcom also has the power to issue directions to ECS or ECN providers relating to the application of the conditions; the directions are published on the Ofcom website as necessary.

New voice services - VoIP

A10.6 In September 2004, Ofcom published a consultation document[139] on new voice services following the emergence of voice services using voice over IP (VoIP). This was followed in February 2006 by a second consultation[140], in response to relevant developments. The February consultation sets out Ofcom's updated proposals for the regulation of new voice telephony services in the light of those relevant developments. In particular, it addresses how different types of VoIP services should be regulated to ensure that consumers' interests can be best protected. Ofcom expects to publish a statement on these issues by the end of 2007. It is likely to include changes to some General Conditions of Entitlement.

Premium rate services (PRS)

A10.7 Under sections 120 of the Communications Act, Ofcom has the power to set conditions relating to the provision, content, promotion and marketing of PRS. These conditions are binding on communications providers of a specified description to comply with directions given in accordance with an approved code by an enforcement authority (which is currently the Independent Committee for the Supervision of Standards of Telephone Information Services (ICSTIS)[141]) and if there are no approved codes the provisions of an order under the Act. ICSTIS regulates the content and promotion of PRS through a Code of Practice which imposes certain specified obligations on both 'service providers' and 'network operators' (as those parties are defined therein).

A10.8 The current version of the Code of Practice was approved for the purposes of sections 120 and 121 of the Act 17th October 2005.

A10.9 The current edition of the ICSTIS Code is available from the ICSTIS website[142].

A10.10 Ofcom recently published its approval under section 121 of the Act of a revised Edition of the ICSTIS Code (11th Edition) on 9 November 2006. The new ICSTIS Coe is due to come into force on 4 January 2005. The new ICSTIS Code is available for viewing on the Ofcom website at: http://www.ofcom.org.uk/consult/condocs/icstiscode/statement/icstis11.pdf.

A10.11 Ofcom is also carrying out a review to consider the scope of PRS regulation, how it should be applied to, or removed from, emerging commercial services in the mobile, fixed telephony and broadcast sectors, as well as from the growth in broadband and VoIP as possible new routes to content.

A10.12 Further information on the regulation of premium rate services is available from both the ICSTIS website and the Ofcom website.

Consumer policy

A10.13 Ofcom is required under the Communications Act 2003 to further the interests of consumers in communications markets "where appropriate by promoting competition". Furthermore, a central premise of Ofcom's approach is that consumer

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[139] See http://www.ofcom.org.uk/consult/condocs/new_voice/.
[140] See http://www.ofcom.org.uk/consult/condocs/voipregulation/.
[141] http://www.icstis.org.uk
[142] See http://www.icstis.org.uk/pdfs/Code_Practice_10_Amended.pdf.

interests can in general be best served by promoting effective competition in the provision of communication services.

A10.14 However, effective competition may not always be enough to ensure that consumer interests are fully served. In order to make informed choices between competing services and providers, consumers need to have information, skills and confidence. They also need to be protected against scams and malpractice that could cause them financial, physical or psychological harm.

A10.15 Ofcom has over the last twelve months increased its efforts to protect consumers from scams and unfair practices and to help enable consumers to benefit from competitive markets through access to information and processes that allow them to switch providers. Ofcom's Consumer Policy statement, to be published in December 2006, sets out its approach to protecting and empowering consumers and the actions Ofcom believes will ensure it is more effective in these areas.

A10.16 In August 2006 Ofcom published consultation proposals to make it easier for customers to change broadband provider through a new General Condition on Services Migrations[143], considering issues relevant to consumers wanting to switch broadband provider. Through its on-going work on Migrations, Switching and Mis-selling[144] Ofcom aims to establish consistent principles on customer migrations and switching across a range of communications services.

Market reviews

A10.17 It is part of Ofcom's duties to carry out regular reviews of particular communications markets, at retail and wholesale level, in accordance with the Framework Directive 2002/21/EC and Commission Recommendation 2003/311/EC. Further details on market reviews may be found on the Ofcom website at http://www.ofcom.org.uk/telecoms/ioi/mrs/ and http://www.ofcom.org.uk/bulletins/crt/compreg_telecoms/.

A10.18 The following markets identified in the Commission Recommendation of 2003 may be of particular relevance to services that could be developed in the available spectrum bands:

a) access and call origination on public mobile telephone networks;

b) voice call termination on individual mobile networks;

c) the wholesale national market for international roaming on public mobile networks; and

d) wholesale broadband access.

A10.19 Other markets identified in the Commission Recommendation may be relevant such as the wholesale market for broadcasting transmission services[145].

[143] See http://www.ofcom.org.uk/consult/condocs/migration/.
[144] See in particular the Policy Evaluation document published on 16 November 2006, available at http://www.ofcom.org.uk/research/tce/tidb/, and the consultation document published on 8 February 2006, available at http://www.ofcom.org.uk/consult/condocs/ocp/.
[145] See Ofcom's statement of 28 April 2005, available at http://www.ofcom.org.uk/consult/condocs/bcast_trans_serv/final.

A10.20 In the case of market a), Oftel carried out a review in 2003 and found that the mobile network operators (MNOs) did not have SMP, either individually or in combination, as described in the corresponding statement of 4 August 2003[146].

A10.21 In the case of market b), Ofcom found in June 2004 each of the 6 MNOs in the UK to have SMP for wholesale voice call termination provided via their respective network[147]. Remedies were imposed on each of the 6 MNOs, as required by the European framework. The remedies varied to some extent between the 6 operators, reflecting (among other things) considerations of proportionality and taking into account the conditions of each network that were relevant at the time. In summary, Ofcom imposed on the 6 MNOs the following remedies:

i) O2, Orange, T-Mobile and Vodafone: charge controls for 2G voice call termination until 31 March 2006;

ii) O2, Orange, T-Mobile and Vodafone: access obligation for 2G voice call termination;

iii) O2, Orange, T-Mobile and Vodafone: obligation not to discriminate unduly in relation to 2G voice call termination;

iv) O2, Orange, T-Mobile and Vodafone: obligations to notify 2G voice call termination charges in advance and to publish Access Contracts;

v) H3G: transparency obligation to notify charges for 2G voice call termination, and to notify 2G and total call volumes[148]; and

vi) Inquam: transparency obligation to notify charges for call termination in advance until it ceased to be an ECS provider and its Wireless Telegraphy Licence was revoked.

A10.22 In June 2005, Ofcom proposed in a consultation[149] to extend the charge controls for 2G call termination for a further 12 months to 31 March 2007. (Other remedies imposed in 2004 remain in place.) Ofcom gave effect to its proposals through its statement of December 2005[150]. Ofcom has also published, in June 2005, a separate consultation document initiating a further market review of voice call termination on individual mobile networks[151]. Following this initial consultation, Ofcom has published in March 2006 a consultation on the review of the mobile call termination market[152] which included preliminary views, however further analysis of

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146 See http://www.ofcom.org.uk/static/archive/oftel/publications/eu_directives/2003/mobileaco0803.pdf.
147 See http://www.ofcom.org.uk/consult/condocs/mobile_call_termination/wmvct/wmvct.pdf.
148 On 29 July 2004, H3G appealed Ofcom's determination finding that H3G has SMP; however, H3G did not appeal Ofcom' s determination as to the relevant market. The Tribunal's judgment was handed down on 29 November 2005. The Tribunal concluded that Ofcom erred in its determination as to the existence of SMP because it did not carry out a full assessment of the extent to which BT had countervailing buyer power. The Tribunal stated, however, that on its reconsideration it would be open to Ofcom to reach the same conclusion. See http://www.catribunal.org.uk/documents/Order1047H3G161205.pdf. Ofcom has reconsidered this matter in accordance with the terms of the consent order approved by the Tribunal at the directions hearing on 16 December 2005 and as drawn on 10 March 2006 and published its proposals for consultation in March and September 2006.
149 See http://www.ofcom.org.uk/consult/condocs/wholesale/.
150 See http://www.ofcom.org.uk/consult/condocs/wholesale/wmvct_statement/.
151 See http://www.ofcom.org.uk/consult/condocs/termination/.
152 See http://www.ofcom.org.uk/consult/condocs/mct/.

some factors was necessary. Ofcom then published an additional detailed consultation on the issues in September 2006[153]. Ofcom expects to conclude this phase of work on mobile call termination by March 2007 when the current regulatory provisions are due to expire.

A10.23 In the case of market c), the European Regulators Group published a framework[154] to help national regulators consider potential competition problems in wholesale roaming markets. Separately, following an announcement by European Commissioner Viviane Reding on 8 February 2006, the Commission initiated a consultation process[155]. On 20 February 2006, it invited comments on the scope of regulation for international roaming. On 3 April 2006, it set out proposals including a discussion of a principle referred to as 'home pricing'. Ofcom responded as part of the ERG's formal responses to the Commission's consultations, on 22 March and 11 May 2006. In its responses the ERG raised a number of concerns with the Commission's approach, and suggested possible alternative approaches for both wholesale and retail regulation.

A10.24 Following the conclusions of the consultations, on 12 July 2006, the EC put forward detailed regulatory proposals[156] in a draft Regulation, setting out proposals to regulate both wholesale and retail charges for roaming within the EU. The draft regulation entered the Co-decision process following publication in July. During this process it will be debated in the European Parliament and the Council of Ministers. Ofcom is liaising with the UK Government in putting forward its views in respect of the draft Regulation as it moves through the Co-decision procedure. Discussions are still ongoing, but are currently expected to conclude in the first half of next year, although this timetable may change.

A10.25 In the case of market d), Ofcom published on 13 May 2004 a statement setting out its findings on SMP and its decisions on regulatory remedies for the wholesale broadband market[157]. Ofcom has now begun a new review of this market to ensure that regulation is appropriate to the prevailing market conditions and published a first consultation document on 21 November 2006[158] covering its approach. It expects to publish a second consultation document in the first half of 2007.

A10.26 Ofcom also has the discretion under the Communications Act to review electronic communications markets other than those described above, and to take action as it determines appropriate. Ofcom has plans to conduct such reviews in the future, including for example a review of the market for wholesale SMS (text messages) termination[159] and a review of the market for wholesale TV broadcasting platforms[160].

[153] See http://www.ofcom.org.uk/consult/condocs/mobile_call_term/.
[154] See ERG(05)20rev1, available at http://erg.eu.int/doc/publications/consult_wholesale_intl_roaming/erg_05_20_rev1_wir_common_position.pdf.
[155] See http://ec.europa.eu/information_society/activities/roaming/roaming_regulation/index_en.htm.
[156] See document COM(2006) 382 final published on 12 July 2006, available at http://ec.europa.eu/information_society/activities/roaming/docs/regulation/regulation_en.pdf.
[157] See http://www.ofcom.org.uk/consult/condocs/wbamp/wholesalebroadbandreview/.
[158] See http://www.ofcom.org.uk/consult/condocs/wbamr/.
[159] See http://www.ofcom.org.uk/telecoms/ioi/mbp/smsreview/.
[160] See http://www.ofcom.org.uk/tv/ifi/marketreviews/wholesaledtvb/ for information on Ofcom's plans.

Other provisions regarding access to networks

A10.27 Ofcom also has the power under the Communications Act to impose access-related conditions. These may include obligations to secure end-to-end connectivity, so that end-users of public ECS may communicate with each other. These obligations may be imposed in some circumstances without a prior finding of SMP.

Numbering

A10.28 Ofcom is responsible for administering the telephone numbers allocated to particular operators under sections 56 to 63 of the Communications Act 2003. Numbers are allocated in accordance with the National Telephone Numbering Plan, which is modified by Ofcom from time to time[161]. Numbers are allocated to operators in blocks of 1,000, 10,000, or 100,000 dependent on their type according to network routing requirements (e.g. mobile numbers are allocated in blocks of 100,000 numbers whilst geographic numbers are allocated in units of 1,000 or 10,000 numbers according to conservation criteria). As operators run out of available numbers (i.e. numbers not sub-allocated by them to customers or otherwise in use) from the ranges allocated to them, they may apply to Ofcom for more.

A10.29 Consistent with the provisions of section 58 of the Communications Act 2003, Ofcom may charge applicants in respect of the allocation to them of telephone numbers. Ofcom published a consultation document on 23 February, entitled "Telephone Numbering – Safeguarding the future of numbers"[162] which included proposals to promote more efficient utilisation of numbering through charging. In July 2006 Ofcom published a further statement indicating that it is still considering the options for charging for numbers and will consult on further proposals in due course.

Network identification codes and number resources for mobile networks

A10.30 Ofcom allocates mobile telephone service numbers and mobile network codes ("MNCs") to those who control mobile communications networks and who, in the case of mobile telephone service numbers, need public numbering for their customers.

A10.31 MNCs are allocated individually in accordance with the National Telephone Numbering Plan ("the Plan")[163] and ITU-T Recommendation E.212[164]. Mobile telephone service numbers are allocated in units of 100,000 numbers for services in accordance with the Plan and ITU-T Recommendations E.212 and E.164. Definitions of these numbers and related services are set out in the Plan published by Ofcom from time to time.

A10.32 Ofcom would expect to allocate MNCs only to public electronic communication network ("PECN") providers. Those operating private networks in conjunction with PECNs will not require their own independent mobile network identity. Their individuality can be demonstrated, where necessary, by location area codes.

[161] See http://www.ofcom.org.uk/telecoms/ioi/numbers/ and http://www.ofcom.org.uk/telecoms/ioi/numbers/100806.pdf for the current version.
[162] See http://www.ofcom.org.uk/consult/condocs/numberingreview/.
[163] See http://www.ofcom.org.uk/telecoms/ioi/numbers/261701.pdf.
[164] Further information may be obtained from the ITU and the relevant webpage is http://www.itu.int/ITU-T/inr/.

Competition in communications markets

A10.33 In addition to its sectoral powers conferred by the Communications Act 2003, Ofcom can also act in relation to communications matters under Chapter I of the Competition Act 1998 and Article 81 of the EC Treaty, to address agreements preventing, restricting or distorting competition, under Chapter II of the Competition Act 1998 and Article 82 of the EC Treaty to address the abuse of a dominant position, and under the Enterprise Act 2002, to address such matters as suspected adverse effects on competition.

A10.34 On 22 September 2005 Ofcom accepted undertakings from British Telecommunications plc pursuant to section 154 of the Enterprise Act 2002[165].

A10.35 Further information about how Ofcom has used these powers can be found on the Ofcom Website, in particular at http://www.ofcom.org.uk/bulletins/comp_bull_index/ and http://www.ofcom.org.uk/bulletins/crt/.

Broadcasting regulation

A10.36 In view of the most likely uses of the spectrum which were identified by Ofcom, this Annex does not contain an explanation of the regulatory regime which governs television and radio broadcasting. Interested parties should seek their own legal advice if they consider that regime to be relevant.

A10.37 In relation to the making television programmes available for reception by members of the public by means of an Electronic Communications Network (ECN), satellite or a radio multiplex, these are licensable under the Broadcasting Act 1990 (as amended) and the Communications Act 2003 as Television Licensable Content Services (TLCS). The delivery technology (DMB, DVB-H, IP etc) is not a determining factor when considering whether a service is licensable as a TLCS.

A10.38 The onus is on the provider of each service (put simply, a TV channel) to determine whether that service requires licensing by Ofcom or not. It is an offence to provide a licensable television service without the appropriate licence.

A10.39 A TV service may be provided by the ECN operator or by another party. It is the provider of the TV service who should hold the Ofcom licence. If a service is already licensed as a TLCS, it does not need a separate TLCS licence to be made available on other ECNs.

A10.40 Once licensed, the television service must comply with all the rules relating to the content and scheduling of programmes and advertising, and the behaviour of licensees, as required by UK and European law.

A10.41 Relevant Codes and Rules for content include:

a) codes published by Ofcom[166]

- the Ofcom Broadcasting Code;
- the Rules on the Amount and Distribution of Advertising;

[165] See http://www.ofcom.org.uk/consult/condocs/statement_tsr/ and http://www.ofcom.org.uk/telecoms/btundertakings/.
[166] See http://www.ofcom.org.uk/tv/ifi/codes/.

- the Code on Electronic Programme Guides;
- the Code on Sports and Listed Events;
- the Code on Access Services; and

b) the BCAP Television Advertising Standards Code[167].

A10.42 If a licensee is found in breach of the Conditions of the TLCS licence, including breaches of the Codes or Rules, Ofcom can impose sanctions on the licensee. Actions Ofcom can take further to a breach range from publication of a finding of the breach, to imposing a statutory sanction on the licensee. Statutory sanctions include obliging the licensee to broadcast Ofcom's finding, financial penalties and revocation of the licence. Further information can be found in Ofcom's Outline procedure on Statutory Sanctions[168].

A10.43 Further information about the licensing process for TLCS licences and the conditions that TLCS licensees are subject to are set out in the Guidance notes for licence applicants. The Guidance notes, along with the standard form TLCS licence, are available on the Ofcom website[169].

A10.44 Examples of recent changes to television broadcasting regulation include:

a) Ofcom's statement of 18 October 2006 on product placement[170]; and

b) Ofcom's statement of 25 October 2006 on rules for channel sponsorship[171].

[167] See http://www.asa.org.uk/asa/codes/.
[168] See http://www.ofcom.org.uk/radio/ifi/ifiguidance/sanctions/.
[169] See http://www.ofcom.org.uk/tv/ifi/tvlicensing/guidance_notes_and_apps/.
[170] See http://www.ofcom.org.uk/consult/condocs/product_placement/statement/.
[171] See http://www.ofcom.org.uk/consult/condocs/sponsorship/statement/.

Annex 11

SUR implementation

Introduction

A11.1 This annex describes in detail the methodology used to calculate the SUR parameters given in Section 9. Assumptions that are made in the process are also mentioned. It builds on the presentation of the concepts of SURs as presented in the SUR consultation document[172].

A11.2 The structure of this section is as follows

- First the general assumptions relevant across all SUR implementations are set out.
- Some general comments on the derivation of each the key SUR parameters are provided, namely the in-band, out-of-band PFD and the indicative interference levels (IILs). A note is included to clarify the interpretation of IILs.
- Next each of the different technologies that considered most likely to be deployed in the different bands considered are discussed – namely the FDD and TDD variants of W-CDMA and PMSE and general information on their operation that will be subsequently used in detailed calculations is provided.
- Finally, the calculation of the SUR parameters for each of the bands under consideration is described, setting out the in-band PFDs, out-of-band PFDs and IILs for each.

Question 20: Do you have any comments on the SUR methodology and assumptions detailed in this annex?

General assumptions

A11.3 As highlighted in the SUR consultation document, for new licences, SUR parameters are derived based on the most likely use of the band.

A11.4 Unless specified otherwise, a number of assumptions applicable to all the bands under consideration have been made:

- Since national licences rather than regional licences will be issued for the bands under consideration, SUR parameters based on geographical interference have not been set.
- It is assumed that all the SUR parameters should not be exceeded at more than 50% of locations in any area, A. Where practicable, the measurement area, A, is also set to cover around 10 ‘cells’ in order that any measurements made are not unduly biased by specific cell placement. A ‘cell’ is assumed to be the coverage area of a transmitter.

[172] http://www.ofcom.org.uk/consult/condocs/sur/

  - o The percentage of locations in the SUR definition is set to 50% because a small number of measurements will be enough to be statistically significant.

  - o The in-band and out-of-band PFD are defined as the average values measured over a period of time sufficiently long to eliminate effects such as fading and the transmission cycle times. The justification for defining the SUR parameters in terms of an average PFD is that it captures variations in time due to propagation effects (e.g. ducting, scatter), activity factor, power control variation, traffic etc. The average PFD approach also has the advantage that any user transmitting high power levels for a short period of time runs the risk of exceeding the average PFD, conversely to setting a PFD based on 50% of time validity.

- The SUR parameters have generally been calculated assuming the measurement area, A, is in an urban environment (It is noted that this is not the case for Aeronautical radionavigation and mobile satellite services as the measurements span a much wider area). While the transmitter power used in an urban environment is likely to be lower than in rural areas, more transmitters are deployed in the former case. It is assumed that an urban environment represents the highest levels of in-band and out-of-band PFD due to the high transmitter deployment density. Hence SUR parameters that are defined based on an urban environment should provide more than adequate interference levels for other environments. There is no intention to provide SURs that differ for different regions.

- In setting the SUR parameters, it is assumed that each channel is owned by different licensees (for the 2.6 GHz band a channel is assumed to be a single 5 MHz lot). This represents the worse case scenario. In the event that a licensee owns two or more contiguous channels, the out-of-band PFD into channels not owned by the licensee is controlled by the SUR parameters.

- Although the in-band and out-of-band PFD is frequency dependent, it is assumed that these quantities which are calculated at a specific frequency are valid across all the bands under consideration. The PFD values are expected to be a few tenths of dBs different across the channels in the bands under consideration.

SUR parameters

In-band PFD

A11.5 The purpose of restricting in-band emissions is to protect a victim receiver from interference received out of its band of operation, caused by in-band emissions from another licence holder.

A11.6 The SUR consultation document describes the procedure used to measure the in-band and out-of-band emissions. In the main, measurements should be made at a uniform grid of points across an area, A, within the victim licensee's geographical operating area. A minimum of 25 measurement locations across area, A, is suggested. This can be increased to achieve greater statistical confidence.

A11.7 Licensees have the choice of either making actual measurements or using a modelling approach to determine whether they or their neighbours are within their SUR limits.

A11.8 The tool used to model SURs - Visualyse, described in Annex 12 - replicates the aforementioned measurement process and is used to generate the expected in-band PFD for the various services of interest. In the future, Ofcom intends to make publicly available a modified version of its Generic Radio Modelling Tool (GRMT) for such calculations. It is expected that this tool will be available well in advance of the 2.6 GHz award. The GRMT is Ofcom's comprehensive propagation tool used to calculate the interference caused by various services in support of Ofcom's liberalisation programme.

Out-of-band PFD

A11.9 The purpose of restricting out-of-band emissions is to protect a victim receiver possibly in the same geographical area from out-of-band emissions from another licence holder operating in a neighbouring frequency band.

A11.10 Unless mentioned otherwise, the out-of-band PFD is determined from the in-band PFD and the Adjacent Channel Leakage Ratio (ACLR). The out-of-band PFD is calculated at regular intervals of 1 MHz from the channel edge. If the channel edge is not an integral multiple of 1 MHz, the out-of-band PFD is calculated at the channel edge and at the next integral multiple of 1 MHz followed by regular intervals of 1 MHz. If the out-of-band PFD changes rapidly over 1 MHz, then the out-of-band PFD is calculated over a smaller increment in frequency.

Indicative interference level (IIL)

A11.11 The indicative interference level (IIL) of a channel represents the anticipated interference levels based on the transmit rights of its adjacent neighbours. However, IILs are only indicative because of the probabilistic nature of propagation and the fact that there may be other sources of noise, such as EMC. It should be noted the IILs are provided for information purposes only and they have no regulatory status. They play a similar roll to Spectrum Quality Benchmarks (SQBs) that have been used elsewhere. IILs quoted in this document are calculated using the best available information that Ofcom has access to at the time. However, Ofcom cannot guarantee that the assumptions used to generate these IILs will remain valid over time and therefore any perspective users of the 2.6 GHz, 2010 MHz and 2290 MHz bands are advised to treat them with a degree of caution.

A11.12 The IIL of a channel is calculated by adding the out-of-band PFD from the all nearby channels which have significant emissions within the channel of interest. These channels will be highlighted on a case by case basis.

A11.13 Depending on the services used in adjacent channels, it is possible that two out-of-band PFD, OOB_1 and OOB_2, into a channel of interest are associated with different measurement areas, A_1 and A_2, respectively; where A_1 is, say, smaller than A_2. In this case, we assume that the out-of-band PFD in the smaller area is valid for a larger area, i.e. we assume that OOB_1 which was measured in area A_1, is valid for an area A_2. The IIL in the above case, which is the sum of OOB_1 and OOB_2, will be associated with area, A_2. Note, however, that this is likely to give a worst-case IIL value as discussed in more detail below.

A11.14 The IIL of a channel is calculated at the height(s) for the assumed height of the receiver used in the channel under consideration. The IIL is calculated at 1.5m and 10m for an unpaired TDD channel, while for a paired FDD down link (DL) channel, the IIL is calculated at 1.5m and for a paired FDD uplink (UL) channel the IIL is calculated at 10m.

A11.15 Unless mentioned otherwise, the computation of the IIL as described above is used for the channels in the bands under consideration.

Interpreting IILs

A11.16 The IIL, as the term suggests, is only indicative and does not represent any form of guarantee. However, it is expected to be of value in network design. Because it is formed by summing all the possible sources of interference, it will likely be worst-case since there may be temporal or geographical situations where not all sources of interference are present. This may be particularly likely where the measurement areas differ for the interfering sources.

A11.17 For example, consider the case where the IIL is comprised of the sum of radar interference and interference from other cellular networks. There is typically only a single radar on a given frequency in an area such as the south-east of the UK and hence a very large SUR measurement area is appropriate. Cellular networks tend to be most densely deployed in urban areas where there are many cells and only a small SUR measurement area is needed. Taking a single IIL value across the larger of these two areas assumes that the cellular network deployment density is constant across the whole of, e.g. the south-east of the UK, and at a level equivalent to that used in London. This is clearly highly unlikely. As a result, a licence holder may wish to make some intelligent interpretations of their IILs. For example, they might expect that:

- In the vicinity of Heathrow Airport where radars are located and a high density cellular network might be deployed, then the IIL level might be reached.
- In central London, the radar signal levels are likely insignificant compared to those from the cellular network, so the IILs will likely be a little lower.
- Outside of urban areas and away from airports, much lower levels of interference might be anticipated in practice.

A11.18 Because IILs are provided for guidance only and their interpretation is up to the licence holder, Ofcom is not intending to attempt to predict their geographical variation. However, Ofcom will indicate each of the sources of interference summed to determine the IIL, facilitating their intelligent interpretation by licence holders.

Background information on the technologies considered most likely to be deployed in these bands

A11.19 In this sub-section, issues relevant to the calculation of the SUR parameters for the most likely uses of the bands under consideration are described, namely FDD DL, FDD UL, TDD and PMSE services.

UMTS FDD Downlink (FDD DL)

A11.20 UMTS FDD is assumed to be the most likely use of paired spectrum in the 2.6 GHz band.

In-band PFD

A11.21 In a downlink scenario, the mobile terminal is to be protected from undue interference. Hence the SUR parameters for an FDD DL channel are applicable at the mobile terminal height, assumed to be 1.5m.

A11.22 To work out the in-band PFD, a number of assumptions need to be made in the SUR modelling tool to model a FDD DL system. These are described in Table 55 of Annex 13.

Out-of-band PFD

A11.23 Unless mentioned otherwise, the out-of-band PFD for an FDD DL channel is calculated based on the in-band PFD and the ACLR for an FDD base station as given in Table 55 of Annex 13. The out-of-band PFD thus calculated is valid up to a frequency offset of 10 MHz from the channel edge. It is assumed that the out-of-band emissions beyond this frequency offset are insignificant. Hence the out-of-band emissions of an FDD DL channel contribute to the IIL of channels within 10 MHz of its channel edge.

Standard FDD DL channel

A11.24 A standard FDD DL channel is defined as one whose in-band and out-of-band PFD are obtained as described above and are shown in Table 30. A standard FDD DL channel provides a level of interference protection to adjacent channels based on the ACLR specified by the 3GPP standards.

Scenario	**Offset from relevant channel edge [MHz]**	**PFD at 1.5m [dBW/m^2/ MHz]**	**PFD at 10m [dBW/m^2/ MHz]**
In-band PFD	NA	-56.6	-53.8
Out-of-band PFD	$-5.0 < \Delta_F \leq -0.0$ (lower edge) $+5.0 > \Delta_F \geq +0.0$ (upper edge)	-101.6	-98.8
Out-of-band PFD	$-10.0 < \Delta_F \leq -5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)	-106.6	-103.8

Table 30: In-band and out-of-band PFD for a standard FDD DL channel (Δ_F is the frequency offset from the relevant channel edge)

UMTS FDD Uplink (FDD UL)

A11.25 UMTS FDD UL is assumed to be the most likely use of paired spectrum in the 2.6 GHz band.

In-band PFD

A11.26 In an uplink scenario, the base station is to be protected from undue interference. Hence the SUR parameters for an FDD UL channel are applicable at the base station height. A standard base station height of 10 m is assumed. A specific base station height for various cellular environments will not be specified.

A11.27 To work out the in-band PFD, a number of assumptions need to be made in the SUR modelling tool to model a FDD UL system. These are described in Table 57 of Annex 13.

Out-of-band PFD

A11.28 Unless mentioned otherwise, the out-of-band PFD for an FDD UL channel is calculated based on the in-band PFD and the ACLR for an FDD mobile terminal as given in Table 57 of Annex 13. The out-of-band PFD thus calculated is valid up to a frequency offset of 10 MHz from the channel edge. It is assumed that the out-of-band emissions beyond this frequency offset are insignificant. Hence the out-of-band emissions of an FDD UL channel contribute to the IIL of channels within 10 MHz of its channel edge.

Standard FDD UL channel

A11.29 A standard FDD UL channel is defined as one whose in-band and out-of-band PFD are obtained as described above and are shown in Table 31. A standard FDD UL channel provides a level of interference protection to adjacent channels based on the ACLR specified by the 3GPP standards.

Scenario	**Offset from relevant channel edge [MHz]**	**PFD at 1.5m [dBW/m^2/ MHz]**	**PFD at 10m [dBW/m^2/ MHz]**
In-band PFD	NA	-68.5	-67.3
Out-of-band PFD	$-5.0 < \Delta_F \leq 0.0$ (lower edge) $+5.0 > \Delta_F \geq 0.0$ (upper edge)	-101.5	-100.3
Out-of-band PFD	$-10.0 < \Delta_F \leq -5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)	-111.5	-110.3

Table 31: In-band and out-of-band PFD for a standard FDD UL channel (Δ_F is the frequency offset from the relevant channel edge)

TDD systems (including UMTS TDD and WiMAX)

A11.30 Based on the Consultants' analysis, it is assumed that UMTS TDD and WiMAX TDD are similar for the purposes of calculating SUR parameters, i.e. they have similar transmitter power, cell radius. For the purposes of defining SUR parameters it is also assume that both services will operate in 5 MHz channels.

A11.31 In a TDD system, the channel is shared in time between uplink and downlink communications. A 50% duty cycle is assumed, i.e. both uplink and downlink share the channel equally in time. If this is not the case in practice, licence holders may need to adjust transmit powers accordingly, If a licensee intends to use the TDD channel for a downlink dominated application, e.g. mobile TV, the licensee has to ensure that its transmit power levels are adjusted so that the PFD specified according to a 50% duty cycle assumption is respected.

A11.32 Since a TDD system consists of both an uplink and a downlink, there will be two sets of SUR parameters for TDD systems. These will be the PFD at the base station and mobile terminal heights.

A11.33 TDD services have been assumed to be the most likely use for the 2010 MHz and 2290 MHz bands and for unpaired spectrum in the 2.6 GHz band. SUR parameters have also been defined for the 2290 MHz band on the assumption that PMSE is used for this band.

A11.34 It is assumed that use of TDD channels is not synchronised as this represents the worst case scenario.

In-band PFD

A11.35 The SUR parameters for TDD systems are specified at the base station and mobile terminal heights, assumed to be 10m and 1.5m respectively.

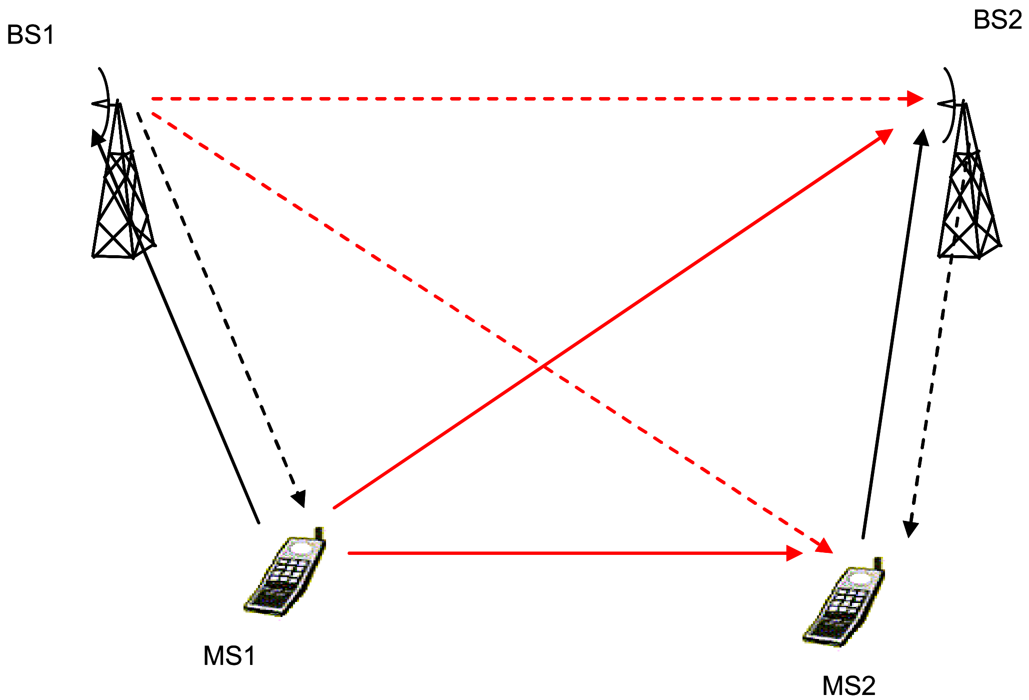


Figure 40: Interference mechanisms between two pairs of BS and MS operating in adjacent TDD channels, 1 and 2. (Black arrows represent a desired communication link and red arrows represent adjacent channel interference)

A11.36 At 1.5m, the dominant interference path is the reception of the downlink from BS1 by MS2. At 10m, the dominant interference path is the reception of the downlink from BS1 by BS2. These dominant interference paths are the ones that have to be controlled by the SUR parameters.

A11.37 To work out the in-band PFD, a number of assumptions need to be made in the SUR modelling tool to model a TDD system. These are described in Table 59 and Table 60 of Annex 13.

A11.38 The in-band PFD for TDD is obtained by including both the uplink and downlink in the TDD simulation run and assuming a 50% duty cycle. Hence during a measurement period of say, 1s, it is expected that the PFD at a test point will include contributions due to both uplink and downlink.

Out-of-band PFD

A11.39 Similarly to the in-band PFD, the out-of-band PFD is obtained by including both the uplink and downlink in the TDD simulation run and assuming a 50% duty cycle. The TDD UL and DL have different ACLR values and the out-of-band emissions due to both uplink and downlink contribute to the PFD measured at the test point during the measurement period.

A11.40 The out-of-band PFD thus calculated is valid up to a frequency offset of 10 MHz from the TDD channel edge. It is assumed that the out-of-band emissions beyond this frequency offset are insignificant. Hence the out-of-band emissions of a TDD channel contribute to the IIL of channels within 10 MHz of its channel edge.

Standard TDD channel

A11.41 A standard TDD channel is defined as one whose in-band and out-of-band PFD are obtained as described above and are shown in Table 32. A standard TDD channel provides a level of interference protection to adjacent channels based on the ACLR specified by the 3GPP standards.

Scenario	Offset from relevant channel edge [MHz]	PFD at 1.5m [dBW/m^2/ MHz]	PFD at 10m [dBW/m^2/ MHz]
In-band PFD	NA	-64.8	-63.7
Out-of-band PFD	$-5.0 < \Delta_F \leq 0.0$ (lower edge) $+5.0 > \Delta_F \geq 0.0$ (upper edge)	-102.2	-101.2
Out-of-band PFD	$-10.0 < \Delta_F \leq -5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)	-112.2	-111.2

Table 32: In-band and out-of-band PFD for a standard TDD channel (Δ_F is the frequency offset from the relevant channel edge)

PMSE

A11.42 It is assumed PMSE services will be one of two most likely services to be used in the 2290-2300 MHz band; the other service being TDD systems.

A11.43 According to the Consultants, potential PMSE uses for the 2290-2300 MHz band are:

- Wireless camera links (as per existing in 2200-2290 MHz)
- City-wide video links (as per existing in 2025-2110 MHz)
- Outside broadcast / electronic news gathering

A11.44 In the absence of other information it is assumed that wireless camera links are the most likely PMSE use.

In-band PFD

A11.45 To work out the in-band PFD, a number of assumptions need to be made in the SUR modelling tool to model a wireless camera link (PMSE). These are described in Table 62 in Annex 13.

Out-of-band PFD

A11.46 The out-of-band PFD is calculated based on the in-band PFD and a DVB-T spectrum mask defined by ETSI EN 300 744 for critical cases of a transmitter operating adjacent to other services. It was considered appropriate to use this mask as it was also used in the analysis of ECC Report 6.

A11.47 The in-band and out-of-band PFD for PMSE services have been calculated at 1.5m and 10m while the wireless cameras (PMSE equipment) have been assumed to operate at a height of 2m. In principle, the SUR parameters and the IIL for a PMSE channel should be specified at a relevant height, i.e. 2m in this case, where protection is offered to a victim receiver. However, for simplicity, it is assumed that the PFD at 2m is the same as the PFD measured at 1.5m.

A11.48 Similarly, it is assumed that the in-band and out-of-band PFD of any service adjacent to PMSE services which have been calculated at 1.5m are also applicable at a height of 2m.

Standard PMSE channel

A11.49 A standard PMSE channel is defined as one whose in-band and out-of-band PFD are obtained as described above and are shown in Table 33. A standard PMSE channel provides a level of interference protection to adjacent channels based on the spectrum mask described above.

Scenario	Offset from relevant channel edge [MHz]	PFD at 1.5m (*) [dBW/m^2/ MHz]	PFD at 10m [dBW/m^2/ MHz]
In-band PFD	NA	-104.8	-98.0
Out-of-band PFD	0.0	-129.9	-123.1
Out-of-band PFD	±0.2	-155.0	-148.2
Out-of-band PFD	±0.4	-156.3	-149.5
Out-of-band PFD	±0.6	-157.7	-150.9
Out-of-band PFD	±0.8	-159.0	-152.2
Out-of-band PFD	±1.0	-160.3	-153.5
Out-of-band PFD	±2.0	-167.0	-160.2
Out-of-band PFD	±3.0	-171.2	-164.4
Out-of-band PFD	±4.0	-175.3	-168.5
Out-of-band PFD	±5.0	-179.5	-172.7

Table 33: In-band and out-of-band PFD for a standard PMSE channel. (*): It is assumed that the PFD at 2m is the same as the PFD measured at 1.5m. (A positive frequency offset is with respect to upper channel edge and a negative offset is with respect to lower channel edge).

A11.50 At a 1 MHz offset from the PMSE channel edge, the out-of-band PFD at 1.5m and 10m correspond to an interference level at an isotropic receiver of -189.7 dBW/ MHz and -182.9 dBW/ MHz respectively. These values correspond to a noise temperature of less than 1K, implying that the out-of-band emissions are below the noise floor. Hence it is assumed that the out-of-band emissions due to PMSE services (assuming wireless cameras use) are negligible.

2500-2690 MHz band

A11.51 In the remaining sub-sections, each of the bands under consideration are analysed and the calculation of SUR parameters for channels at and around the boundary channels is explained in detail.

A11.52 For the purpose of this analysis, a boundary channel is defined as a channel which is either at the band edge or where two disparate services are adjacent to each other.

A11.53 It is possible that boundary channels have restrictions on their use. It is assume that boundary channels which are not at the band edge are allocated to TDD systems and not FDD systems. This is because FDD channels are usually paired and allocating a boundary channel to an FDD system, will imply that another paired FDD channel elsewhere - which does not need restrictions on its use from a spectrum management viewpoint - is unable to be used to the full because of the general need to balance uplink and downlink channels.

A11.54 In order to specify the parameter for boundary channels for each of the bands under consideration, it is necessary to look into the uses adjacent to these bands. This is because it is necessary to assess the impact of the out-of-band emissions from the bands under consideration into the adjacent bands and vice-versa.

A11.55 The SURs below are based on the following channel plan. The position of certain blocks will only be known once the outcome of the award is known.

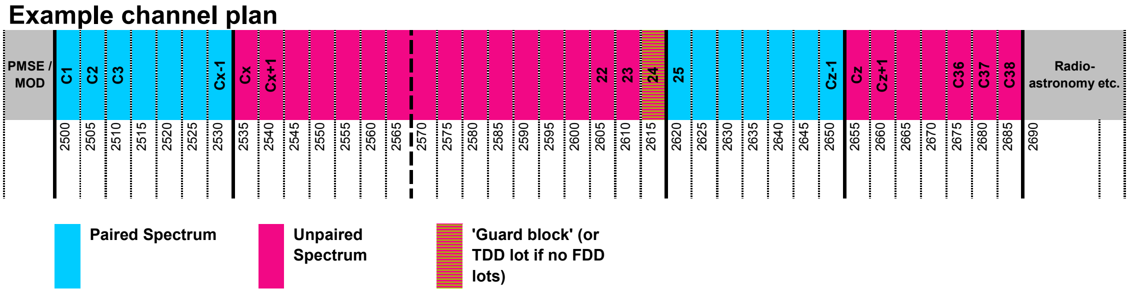


Figure 41: 2.6 GHz Channel plan for SUR parameters

Uses adjacent to the 2500 MHz band edge

A11.56 MoD radiolocation (2450-2500 MHz)

- Information from the MoD indicates they have no current radiolocation assignments in this band. Hence the out-of-band emissions from channels at the bottom of the 2500-2690 MHz band will not affect this service.

- Also, there are no out-of-band emissions from the MoD radiolocation service

A11.57 Short range devices (2450-2483.5 MHz)

- It is assumed that this service will not be affected by out-of-band emissions from the 2500-2690 MHz band due to the frequency separation between the two bands. In addition the SRDs operate under a non-protection basis.

- The out-of-band emissions generated by the SRDs into the 2500-2690 MHz band are considered to be negligible given the power restrictions under which the SRDs operate.

A11.58 PMSE (2450-2500 MHz)

- PMSE services might suffer interference from channels at the bottom of the 2500-2690 MHz band, particularly if these are allocated to TDD services. However, interference can be mitigated against by the use of channel or band filters by PMSE users.

- Similarly to the PMSE analysis described earlier, it is assumed that the most likely use for PMSE bands (2450-2500 MHz, 2025-2110 MHz and 2200-2290 MHz) adjacent to the bands under consideration is wireless camera links. The out-of-band PFD for these PMSE bands into the bands under consideration are assumed to be the same as that described in Table 33.

A11.59 Mobile Satellite-Globalstar (2483.5-2500 MHz)

- Interference analysis by the Consultants indicates that there is a potential for MSS handsets to suffer from interference due to TDD base stations operating in the bottom channels of the 2500-2690 MHz band. Interference due to mobile handsets operating under both TDD and FDD UL services is less significant and is not considered to be a major issue given the relative density of MSS handsets in service.

- The Mobile Satellite – Globalstar band is allocated for the space to Earth link. Given the large distance at which the satellites operate, the out-of-band emissions of the Mobile Satellite-Globalstar band into the 2500-2690 MHz band are not expected to affect services operating at the bottom of the 2500-2690 MHz band.

Boundary channel at the 2500 MHz band edge

A11.60 According to the spectrum packaging options, the most likely uses for the channels at the bottom of the 2500-2690 MHz band are either TDD or FDD UL services. Under the proposed spectrum packaging options, TDD services would operate at the 2500 MHz band edge only if all the channels in the 2500-2690 MHz band are allocated to TDD services.

Case One: Boundary channel C1 allocated to TDD services

A11.61 SURs are specified for the case of TDD services being allocated to the bottom channels of the 2500-2690 MHz band on the basis that the out-of-band emissions from the TDD channels at the bottom of the 2500-2690 MHz band should not exceed a maximum aggregate out-of-band interference threshold experienced by MSS handsets.

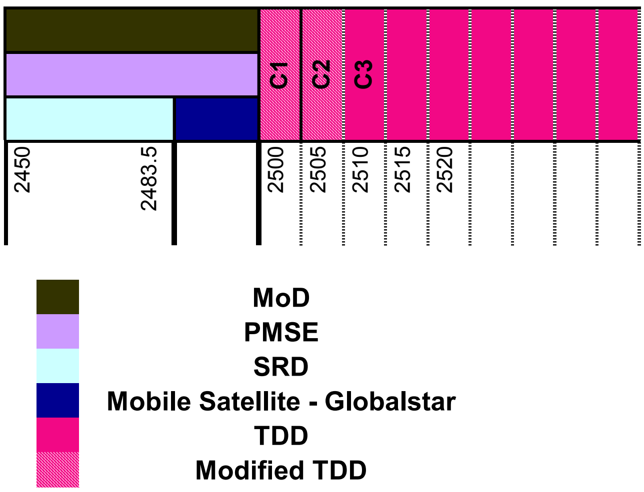


Figure 42: Channels and bands adjacent to the boundary channel C1 which is allocated to TDD services

A11.62 In Case One, it is assumed that the TDD channels at the bottom of the 2500-2690 MHz band offer protection to MSS handsets, in addition to the protection provided through the ACLR limits specified in the 3GPP standards. Based on this assumption, the SUR parameters are analysed for the boundary channel C1 and channels adjacent to it (i.e. channels C2 and C3).

Out-of-band PFD

A11.63 For the scenario where MSS handsets are protected, the out-of-band emissions of the TDD channels C1 and C2 should not exceed a maximum aggregate out-of-band interference threshold experienced by MSS handsets. Hence in Figure 42, channels C1 and C2 are labelled as ‘modified’ TDD channels.

A11.64 The out-of-band PFD from the left boundary of channels C1 and C2, as experienced by the MSS channel, is set at -137.9 dBW/m2/ MHz, i.e. 3 dB less than the maximum aggregate out-of-band interference threshold calculated in Annex 13.

A11.65 However the out-of-band PFD due to the left boundary of channel C2 at channel C1 and the out-of-band PFD from the right boundary of channels C1 and C2 are identical to that of a standard TDD channel. This is because channels C1, C3 and C4 are TDD channels and the protection provided through the ACLR limits specified in the 3GPP standards are adequate.

In-band PFD

A11.66 The in-band PFD of channels C1 and C2 is identical to that of a standard TDD channel. Whilst protecting MSS handsets from out-of-band emissions seen as in-band interference, the same level of protection is not provided for in-band emissions seen as out-of-band interference by the MSS handsets.

IIL

A11.67 Table 34 illustrates the out-of-band PFD contributions to the IIL of TDD channels C1 to C3 at heights of 1.5m and 10m. The out-of-band PFD contributions to the IIL of a channel are denoted by a cross in the appropriate column of channels adjacent to the one in question.

A11.68 The following is helpful in the understanding of Table 34.

- The out-of-band PFD contributions of greyed out cells are not applicable in the calculation of the IIL of the channel in question. E.g. The IIL of channel C3 consists of the out-of-band PFD emitted from the right boundary of channels C1 and C2 and the out-of-band PFD emitted from the left boundary of channels C4 and C5.
- LB and RB stand for the out-of-band PFD emitted from the left boundary and right boundary of a channel respectively.
- A green cross means that the out-of-band PFD of the channel in question is identical to that of a standard channel of the appropriate services.

	Out-of-band PFD [dBW/m^2/ MHz]													
	PMSE(*)		MSS(**)		C1		C2		C3		C4		C5	
IIL	LB	RB	LB	RB	LB	RB	LB	RB	LB	RB	LB	RB	LB	RB
C1		x		x			x		x					
C2						x			x		x			
C3						x		x			x		x	

Table 34: Components of the IIL for TDD channels C1 to C3 at 1.5m and 10m. (*): PMSE channel centred at 2496 MHz. (**): MSS channel centred at 2499.15 MHz.

A11.69 In addition to the assumptions made earlier for each of the relevant services, Table 34 is based on the assumptions listed below.

- The out-of-band PFD of the MSS transmission at 1.5m is the same as that at 10m. This is because free space path loss is likely to be the dominant factor across this link and the difference in height is insignificant compared to the orbital distance of the satellite.

- Only the out-of-band PFD due to the topmost MSS channel (centred at 2499.15 MHz) is relevant to the IIL of channel C1. The out-of-band PFD due to the MSS channel centred at 2499.15 MHz is shown in Table 67 of Annex 13.

- The out-of-band PFD of the PMSE channel centred at 2496 MHz is negligible at channel C2.

A11.70 Assuming the out-of-band PFD due to Aeronautical Radionavigation and Radiolocation services are ignored, the IIL of the TDD channels above C3 are identical to that of channel C3.

A11.71 Table 35 illustrates the IIL calculation for channels C1 to C3 at 1.5m. The out-of-band PFD components in some cases (PMSE and MSS) have been specified over a smaller frequency increment due to the more rapidly changing PFD for these services. Data in the greyed out cells are either insignificant or not applicable.

		OOB at 1.5m [dBW/m^2/ MHz]							IIL at 1.5m [dBW/m^2/ MHz]
Channel	**Freq [MHz]**	**PMSE**	**MSS**	**C1**	**C2**	**C3**	**C4**	**C5**	
C1	2500.0	-129.9	-119.2		-102.2	-112.2			-101.7
C1	2500.2	-155.0	-122.9		-102.2	-112.2			-101.8
C1	2500.4	-156.3	-125.9		-102.2	-112.2			-101.8
C1	2500.6	-157.7	-128.5		-102.2	-112.2			-101.8
C1	2500.8	-159.0	-130.7		-102.2	-112.2			-101.8
C1	2501.0	-160.3	-132.7		-102.2	-112.2			-101.8
C1	2501.2	-160.3	-134.5		-102.2	-112.2			-101.8
C1	2501.4	-160.3	-136.1		-102.2	-112.2			-101.8
C1	2501.6	-160.3	-137.6		-102.2	-112.2			-101.8
C1	2501.8	-160.3	-139.0		-102.2	-112.2			-101.8
C1	2502.0	-167.0	-140.2		-102.2	-112.2			-101.8
C1	2502.2	-167.0	-141.4		-102.2	-112.2			-101.8
C1	2502.4	-167.0			-102.2	-112.2			-101.8
C1	2502.6	-167.0			-102.2	-112.2			-101.8
C1	2502.8	-167.0			-102.2	-112.2			-101.8
C1	2503.0	-171.2			-102.2	-112.2			-101.8
C1	2504.0	-175.3			-102.2	-112.2			-101.8
C2	2505.0			-102.2		-102.2	-112.2		-99.0
C2	2506.0			-102.2		-102.2	-112.2		-99.0
C2	2507.0			-102.2		-102.2	-112.2		-99.0
C2	2508.0			-102.2		-102.2	-112.2		-99.0
C2	2509.0			-102.2		-102.2	-112.2		-99.0
C3	2510.0			-112.2	-102.2		-102.2	-112.2	-98.8
C3	2511.0			-112.2	-102.2		-102.2	-112.2	-98.8
C3	2512.0			-112.2	-102.2		-102.2	-112.2	-98.8
C3	2513.0			-112.2	-102.2		-102.2	-112.2	-98.8
C3	2514.0			-112.2	-102.2		-102.2	-112.2	-98.8

Table 35: Calculation of the ILL for channels C1 to C3 at 1.5m.

A11.72 Table 35 shows that there is no need to specify the IIL of channels C1 to C3 on a per MHz basis and that they can reasonably be specified per channel. A similar argument applies for the IIL calculation at 10m. The IIL at 1.5m and 10m for channels C1 to C3 is shown in Table 36, by rounding up the figures to the nearest integer.

Channel	IIL at 1.5m [dBW/m^2/ MHz]	IIL at 10m [dBW/m^2/ MHz]
C1	-102	-101
C2	-99	-98
C3	-99	-98

Table 36: ILL for TDD channels C1 to C3 at 1.5m and 10m

A11.73 Unless there are significant changes in IIL on a per MHz basis, the IIL is thereafter specified per channel.

Case Two: Boundary channel C1 allocated to FDD UL services

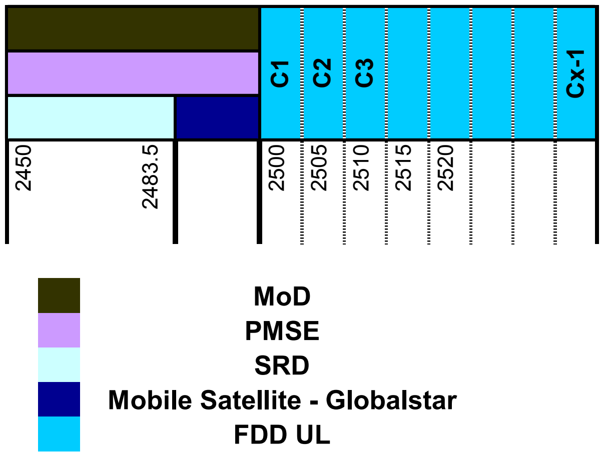


Figure 43: Channels and bands adjacent to the boundary channel C1 which is allocated to FDD UL services

A11.74 In Case Two, it is assumed that the channels at the bottom of the 2500-2690 MHz band are allocated to FDD UL services. Based on this assumption, the SUR parameters are analysed for the boundary channel C1 and channels adjacent to it (i.e. channels C2 and C3).

In-band and out-of-band PFD

A11.75 Interference to MSS handsets from mobile handsets using FDD UL services at the bottom of the 2.6 GHz band is limited to a few tens of metres. This is because the mobile handsets operate at low power levels. The interference is not considered to be a significant issue given the relative density of MSS handsets in service. Hence, no specific protection is provided to the MSS handsets other than the ACLR limits specified in the 3GPP standards.

A11.76 The in-band and out-of-band PFD of channels C1 and C2 are identical to that of a standard FDD UL channel and are shown in Table 31. The same applies to channels above C2.

IIL

A11.77 Table 37 illustrates the out-of-band PFD contributions to the IIL of FDD UL channels C1 to C3 at 10m.

	Out-of-band PFD [dBW/m²/ MHz]													
	PMSE(*)		MSS(**)		C1		C2		C3		C4		C5	
IIL	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**
C1		x		x			x		x					
C2						x			x		x			
C3						x		x			x		x	

Table 37: Components of the IIL for FDD UL channels C1 to C3 at 10m. (*): PMSE channel centred at 2496 MHz. (**): MSS channel centred at 2499.15 MHz.

A11.78 The IIL at 10m for channels C1 to C3 is shown in Table 38, by rounding up the figures to the nearest integer.

Channel	IIL at 10m [dBW/m²/ MHz]
C1	-100
C2	-97
C3	-97

Table 38: ILL for FDD UL channels C1 to C3 at 10m

A11.79 The IIL of the FDD UL channels above C3 is identical to that of channel C3.

Uses adjacent to the 2690 MHz band edge

A11.80 Radio Astronomy/Earth Exploration Satellite/Space Research (2690-2700 MHz)

- Radio Astronomy, Earth Exploration Satellite and Space Research services are not expected to be unduly affected by the out-of-band emissions from the new services in the channels at the top of the 2500-2690 MHz band.

- Radio Astronomy, Earth Exploration Satellite and Space Research are passive services. Hence there will be no out-of-band emissions into 2500-2690 MHz band.

A11.81 Aeronautical Radionavigation and Radiolocation (2700-2900 MHz)

- Aeronautical Radionavigation and Radiolocation services are not expected to be unduly affected by the out-of-band emissions from the new services in the channels at the top of the 2500-2690 MHz band. This is because of the frequency separation and the protection offered by the BS spectrum mask as prescribed by the 3GPP standards.

- The out-of-band PFD due to Aeronautical Radionavigation and Radiolocation into the 2500-2690 MHz band was not available at the time of writing but will be determined prior to any licence award.

Boundary channel at the 2690 MHz band edge (C38)

A11.82 According to the spectrum packaging options, the most likely uses for the channels at the top of the 2500-2690 MHz band can be either TDD or FDD DL services.

Case Three: Boundary channel C38 allocated to TDD services

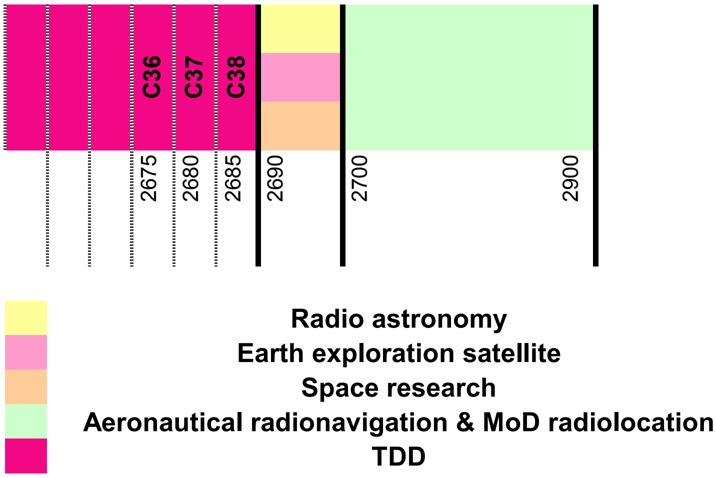


Figure 44: Channels and bands adjacent to the boundary channel C38 which is allocated to TDD services

A11.83 In Case Three, it is assumed that the channels at the top of the 2500-2690 MHz band are allocated to TDD services. Based on this assumption, SUR parameters are analysed for the boundary channel C38 and channels adjacent to it (i.e. channels C36 and C37).

In-band and out-of-band PFD

A11.84 Given that the uses adjacent to the 2690 MHz band edge are not expected to be unduly affected by TDD services operating in the channels at the top of the 2500-2690 MHz band, there are no additional restrictions on the TDD services except for the ACLR limits as specified by the 3GPP standards.

A11.85 The in-band and out-of-band PFD of the TDD channels C35 to C38 (see Figure 44) are identical to those of a standard TDD channel and are shown in Table 32.

A11.86 Under the spectrum packaging options, there are two possibilities whereby channels at the top of the 2500-2600 MHz band are allocated to TDD services:

- TDD services are allocated to all the channels in the 2500-2690 MHz band: The in-band and out-of-band PFD for channels ranging from C1 to C35 have been given in Case One.
- TDD services are allocated to channels Cz to C38: The in-band and out-of-band PFD for channels ranging from Cz to C34 are given in Case Seven.

IIL

A11.87 At the time of writing, the out-of-band PFD emissions from the Aeronautical Radionavigation and Radiolocation services were not available. Assuming these are ignored, Table 39 illustrates the out-of-band PFD contributions to the IIL of TDD channels C35 to C38 at heights of 1.5m and 10m.

	Out-of-band [dBW/m²/ MHz]									
	C34		C35		C36		C37		C38	
IIL	LB	RB	LB	RB	LB	RB	LB	RB	LB	RB
C36		x		x			x		x	
C37				x		x			x	
C38						x		x		

Table 39: Components of the IIL for TDD channels C36 to C38 at 1.5m and 10m

A11.88 The IIL at 1.5m and 10m for channels C36 to C38 is shown in Table 40, by rounding up the figures to the nearest integer.

Channel	IIL at 1.5m [dBW/m²/ MHz]	IIL at 10m [dBW/m²/ MHz]
C36	-99	-98
C37	-99	-98
C38	-102	-101

Table 40: ILL for TDD channels C36 to C38 at 1.5m and 10m

A11.89 Under the spectrum packaging options, there are two possibilities whereby channels at the top of the 2500-2600 MHz band are allocated to TDD services:

- TDD services are allocated to all the channels in the 2500-2690 MHz band: The IIL for channels ranging from C1 to C35 has been given in Case One.
- TDD services are allocated to channels Cz to C38. The IIL for channels ranging from Cz to C34 is given in Case Seven.

Case Four: Boundary channel C38 allocated to FDD DL services

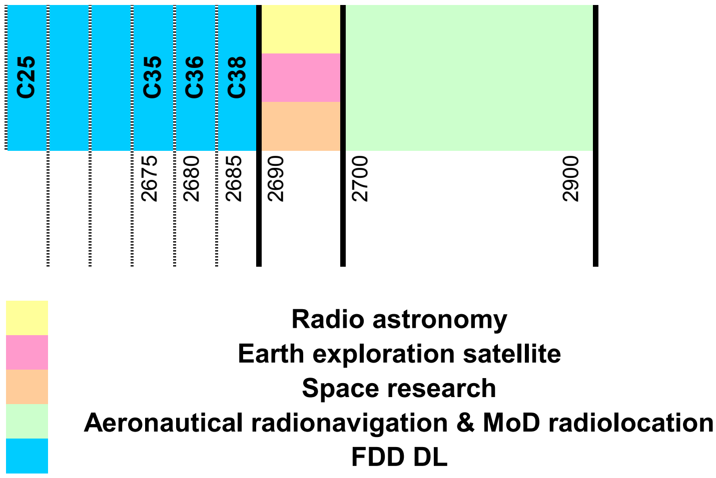


Figure 45: Channels and bands adjacent to the boundary channel C38 which is allocated to FDD DL services

A11.90 In Case Four, it is assumed that the channels at the top of the 2500-2690 MHz band are allocated to FDD DL services. Based on this assumption, the SUR parameters are analysed for the boundary channel C38 and channels adjacent to it (i.e. channels C36 and C37).

A11.91 Given that the uses adjacent to the 2690 MHz band edge are not expected to be unduly affected by FDD DL services operating in the channels at the top of the 2500-2690 MHz band, there are no additional restrictions on the FDD DL services except for the ACLR limit as specified by the 3GPP standards.

In-band and out-of-band PFD

A11.92 The in-band and out-of-band PFD of the FDD DL channels C35 to C38 (see Figure 45) are identical to those of a standard FDD DL channel and are shown in Table 30.

A11.93 This is also applicable to the in-band and out-of-band PFD of the FDD DL channels ranging from C27 to C34. The in-band and out-of-band PFD of the FDD DL channels C25 and C26 are given in Case Six.

IIL

A11.94 At the time of writing, the out-of-band PFD emissions from the Aeronautical Radionavigation and Radiolocation services were not available. Assuming these are ignored, Table 41 illustrates the out-of-band PFD contributions to the IIL of FDD DL channels C35 to C38 at 1.5m.

	Out-of-band [dBW/m^2/ MHz]									
	C34		C35		C36		C37		C38	
IIL	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**
C36		x		x			x		x	
C37				x		x			x	
C38						x		x		

Table 41: Components of the IIL for FDD DL channels C36 to C38 at 1.5m

A11.95 The IIL at 1.5m for channels C36 to C38 is shown in Table 42, by rounding up the figures to the nearest integer.

Channel	**IIL at 1.5m [dBW/m^2/ MHz]**
C36	-97
C37	-98
C38	-100

Table 42: ILL for FDD DL channels C36 to C38 at 1.5m

A11.96 The IIL of the FDD DL channels ranging from C27 to C35 is identical to that of channel C36. The IIL of channels C25 and C26 is given in Case Six.

Boundary channels which are not at the band edge

A11.97 In the 2500-2690 MHz band, there are potentially three boundary channels, Cx, C24 and Cz which are not at the band edge. The SUR parameters at and around these boundary channels are described next.

<u>Case Five: Boundary channel Cx (FDD UL channels adjacent to TDD channels)</u>

A11.98 In Case Five, the SUR parameters are analysed for the boundary channel Cx and the FDD UL and TDD channels adjacent to it.

A11.99 According to one of the spectrum packaging options, channels C1 to Cx-1 can be allocated to FDD UL services and channels Cx to C24 can be allocated to TDD services.

In-band and out-of-band PFD for FDD UL channels (Cx-1 and Cx-2) adjacent to boundary channel Cx

A11.100 The in-band and out-of-band PFD of the FDD UL channels Cx-1 and Cx-2 are identical to those of a standard FDD UL channel and are shown in Table 31.

A11.101 The in-band and out-of-band PFD of the FDD UL channels ranging from C1 to Cx-3 are given in Case Two.

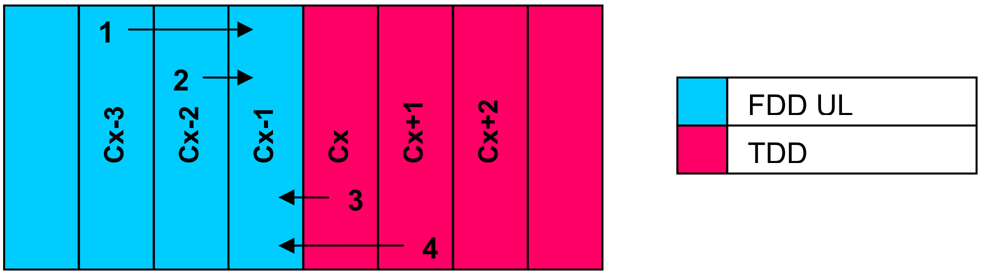
Out-of-band PFD for boundary channel Cx and adjacent TDD channels

A11.102 In principle, the boundary channel Cx is meant to protect adjacent channels allocated to different services, from the TDD channels. From an SUR perspective, this protection is implemented in the following way by considering the FDD UL channel adjacent to the boundary channel, i.e. channel Cx-1.

- We assume that the out-of-band PFD experienced by channel Cx-1 from its right boundary should be less or equal to the out-of-band PFD experienced by channel Cx-1 from its left boundary as illustrated in Figure 46. This restriction applies to the out-of-band PFD at a height of 10m which is of relevance for FDD UL channels.

- On the right boundary of channel Cx-1, the total out-of-band PFD at 10m is given by the sum of out-of-band PFD emitted from the left boundary of channels Cx and Cx+1.

- On the left boundary of channel Cx-1, the total out-of-band PFD at 10m is given by the sum of out-of-band PFD emitted from the right boundary of channels Cx-2 and Cx-3, which are standard FDD UL channels.



Condition required for boundary channel Cx to protect FDD UL channels

Sum of out-of-band PFD experienced by Cx-1 from its right boundary ≤ Sum of out-of-band PFD experienced by Cx-1 from its left boundary, i.e.

Sum of out-of-band PFD due to 3 and 4 ≤ Sum of out-of-band PFD due to 1 and 2

1: Out-of-band PFD from channel Cx-3 at channel Cx-1 = -100.3 dBW/m^2/ MHz
2: Out-of-band PFD from channel Cx-2 at channel Cx-1 = -110.3 dBW/m^2/ MHz
Sum of out-of-band PFD experienced by channel Cx-1 from its left boundary = -99.9 dBW/m^2/ MHz

If the out-of-band PFD due to Cx and Cx+1 at channel Cx-1 was identical to that of a standard TDD channel, then
3: Out-of-band PFD from channel Cx at channel Cx-1 = -101.2 dBW/m^2/ MHz
4: Out-of-band PFD from channel Cx+1 at channel Cx-1 = -111.2 dBW/m^2/ MHz
Sum of out-of-band PFD experienced by channel Cx-1 from its right boundary = - 101.7 dBW/m^2/ MHz

Since the above condition is satisfied, we specify the out-of-band PFD of channels Cx and Cx+1 as being identical to that of a standard TDD channel

Figure 46: Analysis of the out-of-band PFD at 10m as experienced by the FDD UL channel Cx-1

A11.103 The analysis in the above inset (Figure 46) shows that the condition on the out-of-band PFD experienced by channel Cx-1 at 10m is met when the out-of-band PFD of channels Cx and Cx+1 is identical to that of standard TDD channel and is shown in Table 32.

A11.104 The out-of-band PFD of channels Cx and Cx+1 at 1.5m is identical to that of a standard TDD channel. As there are no receivers in an FDD UL channel at a height of 1.5m, the out-of-band PFD of channels Cx and Cx+1 at 1.5m is only specified to their right boundary, i.e. towards other TDD channels.

A11.105 The out-of-band PFD of TDD channels ranging from Cx+2 to C22 is identical to that of a standard TDD channel and is shown in Table 32. The out-of-band PFD of TDD channels C23 and C24 is given in Case Six.

In-band PFD for boundary channel Cx and adjacent TDD channels

A11.106 The in-band PFD for channels Cx and Cx+1 is identical to that of a standard TDD channel and is shown in Table 32.

A11.107 This also applies to the in-band PFD of TDD channels ranging from Cx+2 to C22. The in-band PFD of TDD channels C23 and C24 is given in Case Six.

IIL for boundary channel Cx and adjacent TDD channels

A11.108 Table 43 illustrates the out-of-band PFD contributions to the IIL of TDD channels Cx to Cx+2 at 1.5m and 10m.

	Out-of-band [dBW/m^2/ MHz]													
	Cx-2		Cx-1		Cx		Cx+1		Cx+2		Cx+3		Cx+4	
IIL	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**
Cx		x		x			x		x					
Cx+1				x		x			x		x			
Cx+2						x		x			x		x	

Table 43: Components of the IIL for TDD channels Cx to Cx+2 at 1.5m and 10m

A11.109 The IIL at 1.5m and 10m for channels Cx to Cx+2 is shown in Table 44, by rounding up the figures to the nearest integer.

Channel	IIL at 1.5m [dBW/m^2/ MHz]	IIL at 10m [dBW/m^2/ MHz]
Cx	-98	-97
Cx+1	-99	-98
Cx+2	-99	-98

Table 44: ILL for TDD channels C36 to C38 at 1.5m and 10m

A11.110 The IIL of the TDD channels ranging from Cx+3 to C22 is identical to that of channel Cx+2. The IIL of channels C23 and C24 is given in Case Six.

IIL for the FDD UL channels adjacent to boundary channel Cx

A11.111 Table 45 illustrates the out-of-band PFD contributions to the IIL of FDD UL channels Cx-1 and Cx-2 at 10m.

	Out-of-band PFD [dBW/m²/ MHz]											
	Cx-4		Cx-3		Cx-2		Cx-1		Cx		Cx+1	
IIL	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**
Cx-1				x		x			x		x	
Cx-2		x		x			x		x			

Table 45: Components of the IIL for FDD UL channels Cx-1 and Cx-2 at 10m

A11.112 The IIL at 10m for channels Cx-1 and Cx-2 is shown in Table 46, by rounding up the figures to the nearest integer.

Channel	**IIL at 10m [dBW/m²/ MHz]**
Cx-1	-97
Cx-2	-97

Table 46: ILL for FDD UL channels Cx-1 and Cx-2 at 10m

A11.113 The IIL of FDD UL channels ranging from C1 to Cx-3 is given in Case Two.

Case Six: Boundary channel C24 (TDD channels adjacent to FDD DL channels)

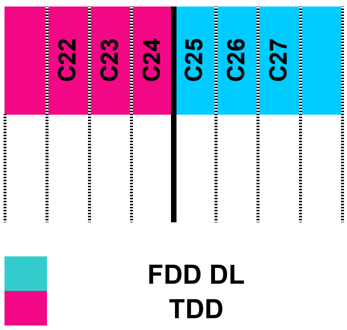


Figure 47: Channels adjacent to the boundary channel C24 which is allocated to TDD services

A11.114 In Case Six (see Figure 47), the SUR parameters are analysed for the boundary channel C24 and the TDD and FDD DL channels adjacent to it.

A11.115 According to one of the spectrum packaging options, channels Cx to C24 can be allocated to TDD services and channels C25 to Cz-1 can be allocated to FDD DL services.

A11.116 The same principle of protecting a non-TDD channel adjacent to a TDD boundary channel as described in A11.102 is applied to the FDD DL channel C25, i.e. the out-of-band PFD experienced by channel C25 from its left boundary should be less or equal to the out-of-band PFD experienced by channel C25 from its right boundary. This restriction applies to the out-of-band PFD at a height of 1.5m which is of relevance for FDD DL channels. Based on this restriction, the in-band and out-of-band PFD for channels ranging from C23 to C26 are given in the next paragraphs.

In-band and out-of-band PFD for FDD DL channels adjacent to boundary channel C24

A11.117 The in-band and out-of-band PFD of the FDD DL channels C25 and C26 are identical to those of a standard FDD DL channel and are shown in Table 30.

A11.118 Under the spectrum packaging options, FDD DL channels may be allocated as follows:

- FDD DL channels occupy channels C25 to Cz-1: In this scenario, the in-band and out-of-band PFD of the FDD DL channels ranging from C27 to Cz-1 are identical to those of a standard FDD DL channel and are shown in Table 30.

- FDD DL channels occupy channels C25 to C38: In this scenario, the in-band and out-of-band PFD of FDD DL channels ranging from C27 to C38 are given in Case Four.

In-band and out-of-band PFD for boundary channel C24 and adjacent TDD channels

A11.119 The condition outlined in A11.116 is met when the out-of-band PFD of the TDD channels C24 and C23 is identical to that of a standard TDD channel and is shown in Table 32.

A11.120 Hence the in-band PFD of channels C24 and C23 is also identical to that of a standard TDD channel and is shown in Table 32.

A11.121 The in-band and out-of-band PFD of TDD channels ranging from Cx to C22 are given in Case Five.

IIL for boundary channel C24 and adjacent TDD channels

A11.122 Table 47 illustrates the out-of-band PFD contributions to the IIL of TDD channels C23 and C24 at 1.5m and 10m. The IIL of TDD channels ranging from Cx to C22 is given in Case Five.

	Out-of-band PFD [dBW/m^2/ MHz]											
	C21		C22		C23		C24		C25		C26	
IIL	LB	RB	LB	RB	LB	RB	LB	RB	LB	RB	LB	RB
C23		x		x			x		x			
C24				x		x			x		x	

Table 47: Components of the IIL for TDD channels C23 and C24 at 1.5m and 10m

A11.123 The IIL at 1.5m and 10m for channels C23 and C24 is shown in Table 48, by rounding up the figures to the nearest integer.

Channel	IIL at 1.5m [dBW/m^2/ MHz]	IIL at 10m [dBW/m^2/ MHz]
Cy-1	-98	-97
Cy	-98	-96

Table 48: ILL for TDD channels C23 and C24 at 1.5m and 10m

IIL for the FDD DL channels adjacent to boundary channel C24

A11.124 Table 49 illustrates the out-of-band PFD contributions to the IIL of FDD DL channels C25 and C26 at 1.5m.

	Out-of-band PFD [dBW/m²/ MHz]											
	C23		C24		C25		C26		C27		C28	
IIL	LB	RB	LB	RB	LB	RB	LB	RB	LB	RB	LB	RB
C25		x		x			x		x			
C26				x		x			x		x	

Table 49: Components of the IIL for FDD DL channels C25 and C26 at 1.5m

A11.125 The IIL at 1.5m for channels C25 and C26 is shown in Table 50, by rounding up the figures to the nearest integer.

Channel	IIL at 1.5m [dBW/m²/ MHz]
Cy+1	-98
Cy+2	-98

Table 50: ILL for FDD DL channels Cy+1 and Cy+2 at 1.5m

A11.126 Under the spectrum packaging options, FDD DL channels may be allocated as follows:

- FDD DL channels occupy channels C25 to Cz-1: In this scenario, the IIL of FDD DL channels ranging from C27 to Cz-3 is identical to that given in Case Four.
- FDD DL channels occupy channels C25 to C38: In this scenario, the IIL of FDD DL channels ranging from C27 to C38 is given in Case Four.

Case Seven: Boundary channel Cz (FDD DL channels adjacent to TDD channels)

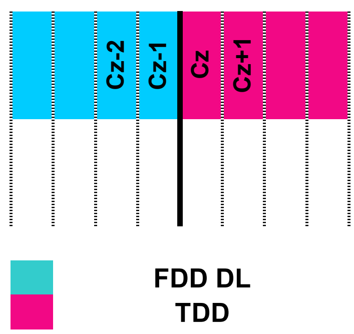


Figure 48: Channels adjacent to the boundary channel Cz which is allocated to TDD services

A11.127 In Case Seven (see Figure 48), the SUR parameters are analysed for the boundary channel Cz and the TDD and FDD DL channels adjacent to it.

A11.128 According to one of the spectrum packaging options, channels C25 to Cz-1 can be allocated to FDD DL services and channels Cz to C38 can be allocated to TDD services.

A11.129 Case Seven is identical to Case Six except that the boundary channel, Cz, in Case Seven has the FDD DL channels to its left while the boundary channel, C24, in Case Six has the FDD DL channels to its right.

A11.130 Hence the in-band and out-of-band PFD and the ILL of channels Cz-3, Cz-2, Cz-1, Cz, Cz+1, Cz+2 are identical to those of channels C27, C26, C25, C24, C23 and C22 respectively as given in Cases Four to Six where appropriate.

A11.131 The in-band and out-of-band PFD and the ILL of channels ranging from Cz+3 to C34 are identical to those of channel Cz+2.

2010-2025 MHz band

A11.132 Ofcom is not proposing to award the 2010-2025 MHz band as multiple 5 MHz lots but rather as a single 15 MHz lot. Hence the 2010-2025 MHz band will be owned by one licensee.

A11.133 TDD services are the most likely use of the 2010-2025 MHz band.

Uses adjacent to the 2010 MHz band edge

A11.134 Mobile Satellite (1980-2010 MHz)

- The ECC Decision (06)01 specifies that the nearest UMTS carrier to the 2010 MHz band edge should be centred on 2013 MHz or above. This is to protect the Mobile Satellite services from out-of-band emissions in the 2010-2025 MHz band by a guard band of 500 kHz.

- Currently there is one partially deployed Mobile Satellite system operating in the 1980-2010 MHz band. For the purposes of calculating SUR parameters it is assume that the out-of-band emissions into the 2010-2025 MHz band are zero.

- The planned EU Decision designating the bands 1980-2010 and 2170-220 MHz to mobile satellite services will come into force within the next year and procedures for selection and authorisation of MSS systems with complementary ground component are under development.

Uses adjacent to the 2025 MHz band edge

A11.135 MoD for mobile and space operations (2025-2110 MHz)

- There is a negligible risk of interference to MoD use from new services in the 2010-2025 MHz band.

- The probability of interference from MoD use to new services in the 2010-2025 MHz band is considered low but cannot be ruled out. Given the absence of further information, we assume that the out-of-band emissions into the 2010-2025 MHz band are zero.

A11.136 PMSE (2025-2110 MHz)

- PMSE services are likely to suffer interference from the 2010-2025 MHz band if it is allocated to TDD services. However PMSE services may be protected by adequate filtering equipment.

- For out-of-band emissions due to PMSE services into the 2010-2025 MHz band, see Table 33.

A11.137 Space Research/Earth Exploration Satellite (2025-2110 MHz)

- The ECC Decision (06)01 specifies that the nearest UMTS carrier to the 2025 MHz band edge should be centred on 2022.2 MHz or below. This is to protect the Space Research and Earth Exploration Satellite services from the out-of-band emissions due to the 2010-2025 MHz band by a guard band of 300 kHz.

- The lowest frequency used by current users of the band in the UK is 2048.877 MHz. Hence we assume that the out-of-band emissions into the 2010-2025 MHz band are zero.

Implications for the 2010-2025 MHz band

A11.138 Given the above conclusions reached with respect to the uses adjacent to the band under consideration, a 500 kHz guard band is required inside the 2010 MHz band edge and a 300 kHz guard band is required inside the 2025 MHz band edge.

A11.139 In principle in an SUR framework, there is no need for guard bands as a means of protection to or from adjacent channels. However in this case, Ofcom respects the ECC Decision (06)01 such that the effective band edges are at 2010.5 MHz and 2024.7 MHz.

A11.140 For the purpose of calculating the SUR parameters, the following assumptions are made:

- The spectrum between 2010.5 MHz and 2024.7 MHz can be divided into a 4.5 MHz channel (2010.5-2015 MHz), a 5 MHz channel (2015-2020 MHz) and a 4.7 MHz channel (2020-2024.7 MHz). All three channels are owned by the same licensee.

- The in-band PFD of the 4.5 MHz and 4.7 MHz channels is identical to the in-band PFD - specified with a reference bandwidth of 1 MHz, i.e. in units of dBW/m^2/ MHz - of the 5 MHz channel. This implies that the first two channels operate at a lower power than the 5 MHz channel.

- The ACLR limit of the 4.5 MHz and 4.7 MHz channels is identical to that of the 5 MHz channel.

- There are no further restrictions on the TDD channels in the 2010-2025 MHz band in addition to the guard bands and ACLR limits as mentioned above.

A11.141 Although the in-band and out-of-band PFD of the 2010-2025 MHz band are obtained based on the assumption of constituent channels, these quantities are specified for the whole of the 2010-2025 MHz band rather than for the constituent channels.

<u>In-band PFD</u>

A11.142 Based on the above assumptions, the in-band PFD for the 2010-2025 MHz band is identical to the in-band PFD of a standard TDD channel as shown in Table 32.

Out-of-band PFD

A11.143 Since the three channels in the 2010-2025 MHz band will be owned by the same licensee, the out-of-band PFD at the boundary with the guard bands is specified, i.e. at 2010.5 MHz and at 2024.7 MHz.

A11.144 The out-of-band PFD from the 2010-2025 MHz band at the 2010.5 MHz boundary consists of the out-of-band PFD due to the 2010.5-2015 MHz and 2015-2020 MHz channels. In both cases, the out-of- band PFD extends to a 10 MHz offset from the relevant channel edge, i.e. down to 2000.5 MHz for the former and 2005 MHz for the latter.

A11.145 The out-of-band PFD from the 2010-2025 MHz band at the 2024.7 MHz boundary consists of the out-of-band PFD due to the 2020-2024.7 MHz and 2015-2020 MHz channels. In both cases, the out-of- band PFD extends to a 10 MHz offset from the relevant channel edge, i.e. up to 2034.7 MHz for the former and 2030 MHz for the latter.

A11.146 Based on the above assumptions, the out-of-band PFD at 1.5m and 10m due to TDD services as the most likely use within 2010.5 MHz to 2024.7 MHz is shown in Table 51. The out-of-band PFD have been rounded up to the nearest integer.

Scenario	Offset from relevant boundary [MHz]	PFD at 1.5m [dBW/m^2/ MHz]	PFD at 10m [dBW/m^2/ MHz]
Out-of-band PFD	$-0.5 < \Delta_F \leq 0.0$ (2010.5 MHz boundary) $+0.3 > \Delta_F \geq 0.0$ (2024.7 MHz boundary)	-99	-98
Out-of-band PFD	$-5.0 < \Delta_F \leq -0.5$ (2010.5 MHz boundary) $+5.0 > \Delta_F \geq +0.3$ (2024.7 MHz boundary)	-102	-101
Out-of-band PFD	$-5.5 < \Delta_F \leq -5.0$ (2010.5 MHz boundary) $+5.3 > \Delta_F \geq +5.0$ (2024.7 MHz boundary)	-109	-108
Out-of-band PFD	$-10.0 < \Delta_F \leq -5.5$ (2010.5 MHz boundary) $+10.0 > \Delta_F \geq +5.3$ (2024.7 MHz boundary)	-112	-111

Table 51: Out-of-band PFD due to TDD services as the most likely use within 2010.5 MHz and 2024.7 MHz. (Δ_F is the frequency offset from the relevant boundary)

IIL

A11.147 Further work is needed to define the IILs for the 2010 MHz band. Ofcom will publish further details in due course.

2290-2300 MHz band

A11.148 Ofcom is not proposing to award the 2290-2300 MHz band as multiple 5 MHz lots but rather as a single 10 MHz lot. Hence the 2290-2300 MHz band will be owned by one licensee.

A11.149 There are two most likely uses for the 2290-2300 MHz band, namely TDD and PMSE services.

Uses adjacent to the 2290 MHz band edge

A11.150 MoD for mobile and space operations (2200-2290 MHz)

- There is a negligible risk of interference to MoD use from new services in the 2290-2300 MHz band.

- The probability of interference from MoD use to new services in the 2290-2300 MHz band is considered low but cannot be ruled out. Given the absence of further information, it is assumed that the out-of-band emissions into the 2290-2300 MHz band are zero.

A11.151 PMSE (2200-2290 MHz)

- PMSE services are likely to suffer interference from the 2290-2300 MHz band if it is allocated to TDD services. However PMSE services may be protected by adequate filtering equipment. If the 2290-2300 MHz band is allocated to PMSE services, use of the PMSE services can be factored in the network planning process with the PMSE users in the adjacent 2200-2290 MHz band.

- For out-of-band emissions due to PMSE services into the 2290-2300 MHz band, see Table 33.

A11.152 Space Research/Earth Exploration Satellite (2200-2290 MHz)

- No current use is being made of the 2200-2290 MHz band for Space Research and Earth Exploration Satellite services. Hence we assume that the out-of-band emissions from the 2290-2300 MHz band to the Space Research and Earth Exploration Satellite band will not cause any interference.

- Similarly, we assume that the out-of-band emissions into the 2290-2300 MHz band are zero.

Uses adjacent to the 2300 MHz band edge

A11.153 The 2300-2302 MHz band is not intended to be awarded as part of this spectrum award.

A11.154 Emergency services – Fixed links (2302-2310 MHz)

- We also note that the 2302-2310 MHz band is likely to be cleared and made available for civil use in the future.

- Given that there is a low density of Fixed link sites it is unlikely that TDD or PMSE users will be in the neighbourhood of these sites. Hence the out-of-band emissions from the 2290-2300 MHz band are assumed not to be a source of significant interference.

- For reasons given above, it is also assumed that the out-of-band emissions from users of the Emergency services band are negligible.

Implications for the 2290-2300 MHz band

TDD services as most likely use for the 2290-2300 MHz band

A11.155 As before, although the in-band and out-of-band PFD of the 2290-2300 MHz band are obtained based on the assumption of constituent channels, these quantities are specified for the whole of the 2290-2300 MHz band rather than for the constituent channels. This implies that the out-of-band PFD is specified as from the band edges.

In-band PFD

A11.156 For the purpose of calculating the SUR parameters, the following assumptions are made:

- The 2290-2300 MHz band consists of two 5 MHz channels owned by the same licensee.
- The in-band PFD for the 2290-2300 MHz band is identical to the in-band PFD of a standard 5 MHz TDD channel as shown in Table 32. This assumption is valid if a uniform EIRP is used across the 2290-2300 MHz band and is the same as the EIRP assumed for a standard 5 MHz TDD channel.

Out-of-band PFD

A11.157 The out-of-band PFD from the 2290-2300 MHz band at the 2290 MHz band edge consists of the out-of-band PFD due to the 2290-2295 MHz and 2295-2300 MHz channels. In both cases, the out-of- band PFD extends to a 10 MHz offset from the relevant channel edge, i.e. down to 2280 MHz for the former and 2285 MHz for the latter.

A11.158 The out-of-band PFD from the 2290-2300 MHz band at the 2300 MHz band edge consists of the out-of-band PFD due to the 2290-2295 MHz and 2295-2300 MHz channels. In both cases, the out-of- band PFD extends to a 10 MHz offset from the relevant channel edge, i.e. up to 2305 MHz for the former and 2310 MHz for the latter.

A11.159 Based on the above assumptions, the out-of-band PFD at 1.5m and 10m due to TDD services as the most likely use within the 2290-2300 MHz band is shown in Table 52. The out-of-band PFD have been rounded up to the nearest integer.

Scenario	Offset from relevant band edge [MHz]	PFD at 1.5m [dBW/m^2/ MHz]	PFD at 10m [dBW/m^2/ MHz]
Out-of-band PFD	$-5.0 < \Delta_F \leq 0.0$ (lower band edge) $+5.0 > \Delta_F \geq 0.0$ (upper band edge)	-102	-101
Out-of-band PFD	$-10.0 < \Delta_F \leq -5.0$ (lower band edge) $+10.0 > \Delta_F \geq +5.0$ (upper band edge)	-112	-111

Table 52: Out-of-band PFD due to TDD services as the most likely use within the 2290-2300 MHz band. (Δ_F is the frequency offset from the relevant band edge)

IIL

A11.160 Further work is needed to define the IILs for the 2290 MHz band. Ofcom will publish further details in due course.

PMSE services as most likely use for the 2290-2300 MHz band

A11.161 For the purpose of calculating the SUR parameters, it is assumed that the PMSE channel in the 2290-2300 MHz band is centred at 2295 MHz and has a bandwidth of 8 MHz as used in Annex 13.

A11.162 Given the above conclusions reached with respect to the uses adjacent to the band under consideration, there are no additional restrictions on the PMSE services in the 2290-2300 MHz band except for the spectrum mask as assumed in A.11.46.

In-band and out-of-band PFD

A11.163 The in-band and out-of-band PFD for the 2290-2300 MHz band are identical to those of a standard PMSE channel and are shown in Table 53 below. The figures have been rounded up to the nearest integer and the out-of-band PFD is specified from the band edges.

Scenario	**Offset from relevant band edge [MHz]**	**PFD at 1.5m (*) [dBW/m^2/ MHz]**	**PFD at 10m [dBW/m^2/ MHz]**
In-band PFD	NA	-105	-98
Out-of-band PFD	$-1.0 < \Delta_F \leq 0.0$ (lower band edge) $+1.0 > \Delta_F \geq 0.0$ (upper band edge)	-160	-154
Out-of-band PFD	$-2.0 < \Delta_F \leq -1.0$ (lower band edge) $+2.0 > \Delta_F \geq +1.0$ (upper band edge)	-167	-160
Out-of-band PFD	$-3.0 < \Delta_F \leq -2.0$ (lower band edge) $+3.0 > \Delta_F \geq +2.0$ (upper band edge)	-171	-164
Out-of-band PFD	$-4.0 < \Delta_F \leq -3.0$ (lower band edge) $+4.0 > \Delta_F \geq +3.0$ (upper band edge)	-175	-169
Out-of-band PFD	$-5.0 < \Delta_F \leq -4.0$ (lower band edge) $+5.0 > \Delta_F \geq +4.0$ (upper band edge)	-180	-173

Table 53: In-band and out-of-band PFD due to PMSE services as the most likely use within the 2290-2300 MHz band. Δ_F is the frequency offset from the relevant band edge. (*): We assume that the PFD at 2m is the same as the PFD measured at 1.5m.

IIL

A11.164 Further work is needed to define the IILs for the 2290 MHz band. Ofcom will publish further details in due course.

Annex 12

SUR modelling tool

Introduction

A12.1 The Transfinite Visualyse Professional tool has been used to model SURs. It replicates the measurement process that can be used to obtain the SUR parameters. Visualyse is used to generate the expected in-band PFD for the various services of interest. In the future, Ofcom intends to make publicly available a modified version of its Generic Radio Modelling Tool (GRMT) for such calculations. The GRMT is Ofcom's comprehensive propagation tool used to calculate the interference caused by various services in support of Ofcom's liberalisation programme.

A12.2 Visulayse is a tool that can model radio communication systems (terrestrial and satellite) across a frequency range of 100 MHz to 100 GHz. Hence it is well suited to model the services that are of relevance to this spectrum award.

Question 21: Do you have any comments on the use of the Visualyse tool as described, on the assumptions or the propagation model proposed in this annex?

Modelling methodology

A12.3 To illustrate how Visualyse is used, the modelling methodology used to derive the in-band PFD for the cellular services is described, i.e. FDD DL, FDD UL and TDD.

A12.4 The methodology is underpinned by the chosen system parameters, the deployment assumptions and the propagation model used in the simulation. These will vary depending on the service being modelled and are provided for each of the relevant services to this spectrum award in Annex 11.

Selection of parameters

A12.5 The accuracy of simulation techniques depends upon the selection of input parameters. In order to calculate PFD levels in computer models, it is necessary to have all relevant parameters well defined. The assumptions made can have a significant impact on the results and care is needed in their selection. A number of principles were applied as shown below:

- Parameters and modelling methods should be based upon documents that are in the public domain.
- These documents should have been subject to a process such as peer review that gives confidence in their use.
- Selection of parameters and modelling methodology should take account of how the PFD masks would be used – in particular as a regulatory tool that could be checked by measurement.

A12.6 The main sources of parameters used for the calculation of the PFD for cellular services are:

- ERC Report 45: Sharing and adjacent band compatibility between UMTS / IMT-2000 in the band 2 500 – 2 690 MHz and other services

- 3GPP 25.101: Technical Specification Group Radio Access Networks; UE Radio Transmission and Reception (FDD)

- 3GPP 25.102: Technical Specification Group Radio Access Networks; UE Radio Transmission and Reception (TDD)

- 3GPP 25.104: Technical Specification Group Radio Access Networks; BS Radio Transmission and Reception (FDD)

- 3GPP 25.105: Technical Specification Group Radio Access Networks; BS Radio Transmission and Reception (TDD)

A12.7 Within these documents a number of alternative scenarios for each of the three bands have been defined. For example there are different scenarios depending upon whether modelling the 3G network in urban, suburban or rural areas, and whether the call traffic is pedestrian or vehicular and whether voice or data

A12.8 It is generally accepted that field strengths in high density urban areas are higher than for rural areas and that rural cells are coverage limited whereas urban areas are noise limited due to the aggregation of large numbers of users. Hence a PFD mask that is defined for urban areas is expected in general to be higher than the equivalent for rural areas.

A12.9 Therefore it is assumed that if the regulatory regime defines a single mask it can be derived for high density urban areas and applied to all conditions.

A12.10 The parameters selected for each scenario are described in detail in Annex 13. Some simplifying assumptions were made – for example use of isotropic gain patterns rather than detailed shaped ones. However test runs comparing the results with isotropic vs. another gain pattern (based upon ITU-R Rec. F.1336) showed only minor differences in the resulting PFD mask.

A12.11 The simulations took into account variations due to power control by taking the typical EIRP rather than maximum EIRP: however both numbers are given in the parameter tables in Annex 13 and there should be a linear impact on the resulting PFD mask.

A12.12 Note that two pairs of PFD masks were generated for both the in-band and out-of-band cases. One pair of masks was generated assuming measurements are to be made at 1.5m above local terrain and another pair for a height of 10m. Hence each scenario involved four PFD masks in total.

A12.13 All PFD masks were calculated assuming a reference bandwidth of 1 MHz and uniform WCDMA spectral density across the 5 MHz.

Deployment assumptions

A12.14 In order to calculate PFD levels it is necessary to know the locations of transmitters and receivers and predict how the radio waves propagate from one to the other. In general there are two possible approaches that could be used:

- Model a specific location in depth – for example taking into account the impact of terrain and buildings

- Model a generic location using a statistical approach – for example one that averages the results from many specific locations

A12.15 There would be a danger in taking the first approach in that the results might be atypical due to unusual characteristics of the site selected. Hence the second approach was chosen, though attention was made to assessing the variations that could be expected for particular locations.

A12.16 Hence it was considered appropriate to use a geometric “ideal” deployment of base stations in a hexagonal cellular structure and deployment of users at random with constant density per cell as in Figure 49 below.

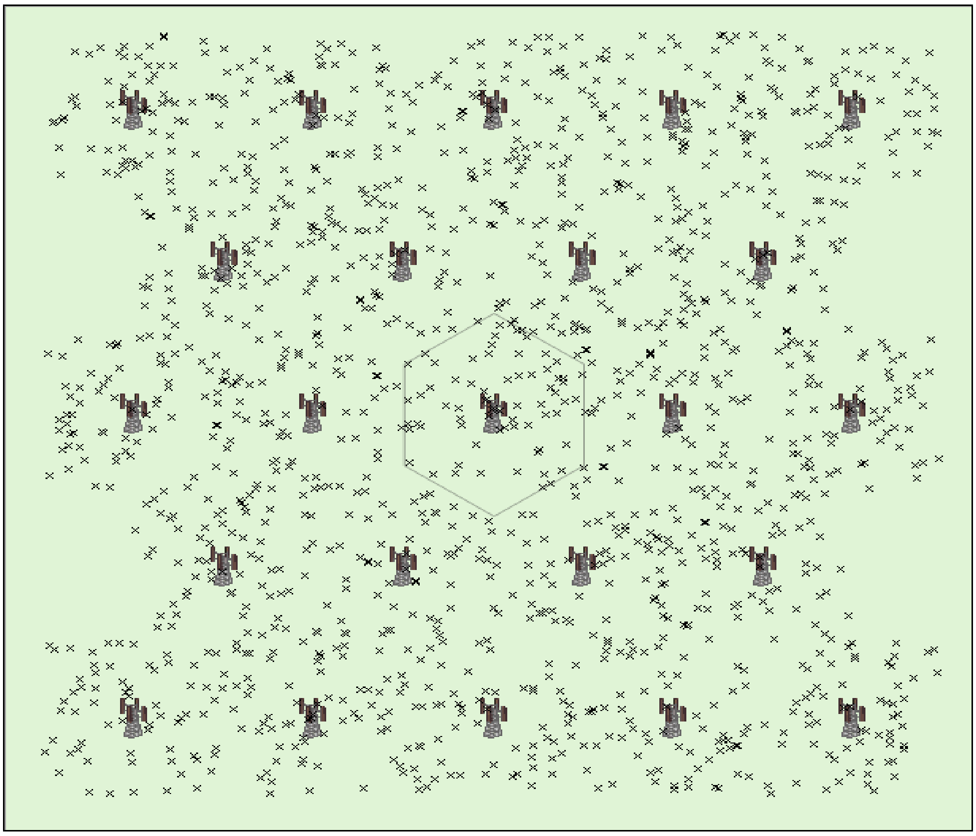


Figure 49: Location of base stations and users in test deployment

A12.17 The PFD measure is defined as an aggregate from all possible transmitters – in theory this could require the inclusion of all co-frequency transmitters nationwide. As this is computationally infeasible it is typically necessary to limit simulations to a manageable set – in the figure above there are 23 base stations and 1495 mobile users.

A12.18 Furthermore it is noted that receivers at the centre are likely to experience a greater degree of aggregation than those at the outskirts – the so-called “edge effect”. In order to remove this bias the test area assumed for measurement of the PFD was the central cell, shown as a hexagon in Figure 50, with test points arranged in a grid as in Figure 50.

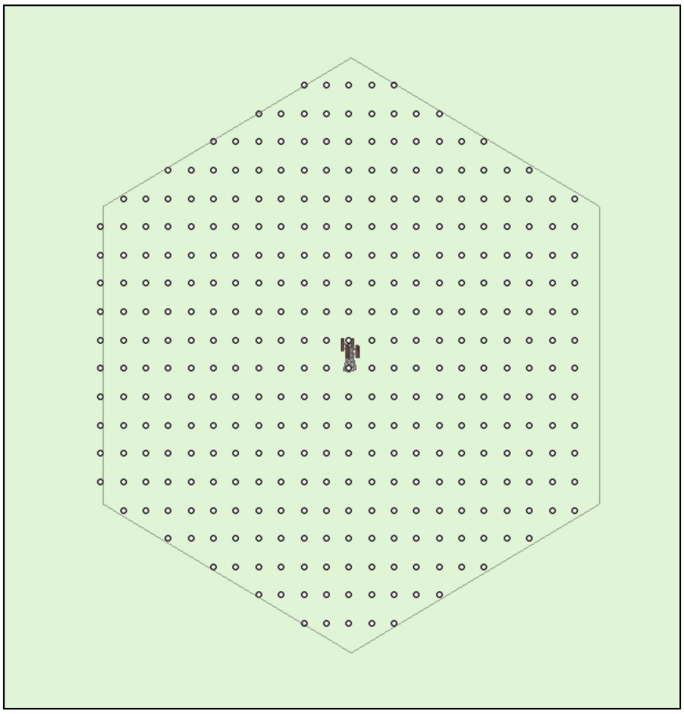


Figure 50: Grid of test points to calculate PFD

Propagation models

A12.19 For such a generic approach it was not considered appropriate to use site specific models, such as those in ITU-R Recs. P.452 & P.1411 or various ray tracing techniques. Furthermore models such as those in ITU-R Rec.P.1546 or Hata / COST 231 are only defined for distances above 1 km, whereas for urban areas this is the critical range.

A12.20 Hence it was considered more appropriate to use a generic model that took account of the nature of propagation in urban areas, namely:

- Close to the transmitter the path is likely to be line of sight and hence should be modelled as free space path loss
- There will be a break point which is height dependent after which there is less likely to be line of sight between transmitter and receiver
- Beyond this break point signals will attenuate faster than free space path loss and so the slope of the distance vs. loss curve will change
- There is likely to be significant variation in the signal at a specified distance from a transmitter due to differences in building orientation and multi-path effects

A12.21 Hence a suitable model was considered to be a dual slope propagation model with additional log-normal variation, defined mathematically as:

$$L_{DS} = L_{FS}(d) + L_N(B) \qquad \text{for } d \leq d_0$$

$$L_{DS} = L_{FS}(d_0) + A.10.\log_{10}\left(\frac{d}{d_0}\right) + L_N(B) \qquad \text{for } d > d_0$$

where:

$$L_{FS} = 32.45 + 20\log_{10}(f_{MHz}) + 20.\log_{10}(d_{km})$$

$L_N(B)$ = log-normal distribution mean zero & standard deviation B

A12.22 The introduction of a log-normal term can lead to very low path losses close to the transmitter – much less than free space path loss. As this is unrealistic the loss was capped at free space path loss.

A12.23 It is then important to ensure the appropriate values of A, B and d_0 are selected. These will depend upon the environment (urban, suburban, rural) and height of transmitter and receiver.

A12.24 There has been significant measurement of propagation in urban environments and derivation of best-fit parameters to models such as those described above. A number of such derivations are documented in “Wireless Communications Principles & Practice” by Theodore Rappaport. While none matched Ofcom’s precise requirements, the following set of values listed in Table 54 were considered consistent with the data available.

TX-RX Heights	High-High	High-Low Low-High	Low-Low
First slope	2	2	2
Break point	200 m	100 m	50 m
Second slope	3	3.5	4
Variation	8 dB	8 dB	8 dB

Table 54: Propagation model parameters

A12.25 Graphs of the median loss vs. distance (i.e. excluding the log-normal variation) for these three models are shown in Figure 51.

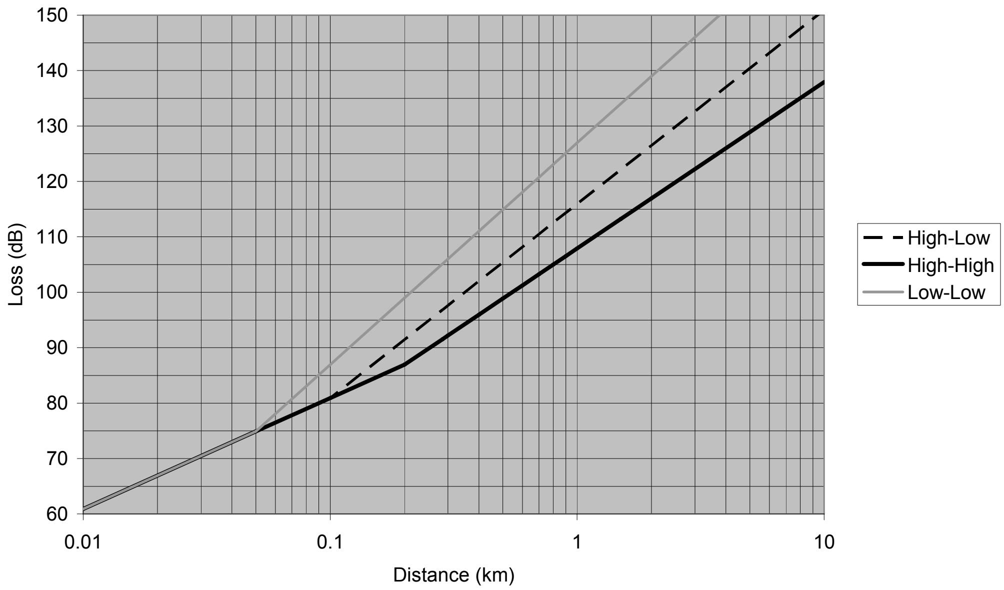


Figure 51: Generic dual slope propagation models

A12.26 Introducing a random element via the log-normal factor implies that the simulation could predict different PFD masks if generated from a different set of random numbers. This reflects the reality of measurement – a set of N measurements on one day is likely to give a different set of results to those on another day.

A12.27 To ensure that the PFD can be used as a regulatory tool to check a licensee's deployment it is necessary to include this effect in the prediction methodology. Hence a set of N=5 separate simulations were done in each case and the average PFD was determined.

Annex 13

Assumptions and inputs used in the SUR modelling tool

Introduction

A13.1 The modelling methodology described in Annex 11 is underpinned by the chosen system parameters, the deployment assumptions and the propagation models used.

A13.2 In this Annex, the above information used in the modelling by Visualyse for the following services is provided, namely FDD DL, FDD UL, TDD, PMSE and Mobile Satellite – Globalstar.

Question 22: Do you have any comments on the assumptions detailed in this annex?

FDD DL

A13.3 The parameters used to derive the FDD DL PFD mask are given in Table 55.

Field	Value	Comments
Frequency	2.65 GHz	Consistent with proposed channel plan
Bandwidth	5 MHz	WCDMA channel
Base station maximum power	38 dBm	Typical transmit power for Pedestrian Micro FDD scenario from ECC Report 45.
Base station typical power	35 dBm	Typical transmit power for Pedestrian Micro FDD scenario from ECC Report 45. Includes 3 dB power control factor.
Adjacent channel leakage power ratio (ACLR)	45 dB and 50 dB at a 5 MHz and 10 MHz offset from carrier frequency respectively	From 3GPP TS 25.104.
Base station peak gain	5 dBi	From ECC Report 45. Hence EIRP = 40 dBm
Base station height	10 m	Standard height
Cell shape	Hexagon	As in figure above
Cell radius	0.315 km	Based upon ERC Report 45

Table 55: WCDMA FDD DL parameters

A13.4 The measurement area and parameters for FDD DL, FDD UL and TDD cases are given by:

- Measurement area: 1 hexagonal cell (i.e. 34 km^2 for FDD DL, 34 km^2 for FDD UL and 0.14 km^2 for TDD).
- Number of measurement points: 342 (These are uniformly deployed across the hexagonal central cell
- Measurement period: ~ 1s (significantly longer than an FDD or TDD time frame).

A13.5 The propagation model used for the FDD DL, FDD UL and TDD cases is defined in A12.21 and the propagation parameters are listed in Table 54.

A13.6 Based on the above inputs and assumptions, the in-band and out-of-band PFD due to a standard FDD DL channel are given in Table 56.

Scenario	Offset from relevant channel edge [MHz]	PFD at 1.5m [dBW/m^2/ MHz]	PFD at 10m [dBW/m^2/ MHz]
In-band PFD	NA	-56.6	-53.8
Out-of-band PFD	$-5.0 < \Delta_F \leq -0.0$ (lower edge) $+5.0 > \Delta_F \geq +0.0$ (upper edge)	-101.6	-98.8
Out-of-band PFD	$-10.0 < \Delta_F \leq -5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)	-106.6	-103.8

Table 56: In-band and out-of-band PFD for a standard FDD DL channel (Δ_F is the frequency offset from the relevant channel edge)

FDD UL

A13.7 The parameters used to derive the FDD UL PFD mask are given in Table 57.

Field	Value	Comments
Frequency	2.52 GHz	Consistent with proposed channel plan
Transmit bandwidth	5 MHz	WCDMA channel
Maximum transmit power	9.6 dBm	Derived from ECC Report 45 typical power assuming 3 dB of power control
Typical or average transmit power	6.6 dBm	From ECC Report 45
Adjacent channel leakage power ratio (ACLR)	33 dB and 43 dB at a 5 MHz and 10 MHz offset from carrier frequency respectively	From 3GPP TS 25.101
Transmit antenna height	1.5 m	Standard assumption for mobiles
Transmit peak gain	0 dBi	Standard assumption for mobiles Hence EIRP = 6.6 dBm
Cell shape	Hexagon	As in figure above
Cell radius	0.315 km	From ERC Report 45
Maximum number of simultaneously active mobiles per cell	65	From ECC Report 45

Table 57: WCDMA FDD UL parameters

A13.8 The propagation model used for the FDD DL, FDD UL and TDD cases is defined in A12.21 and the propagation parameters are listed in Table 54.

A13.9 Based on the above inputs and assumptions, the in-band and out-of-band PFD due to a standard FDD UL channel are given in Table 58.

Scenario	Offset from relevant channel edge [MHz]	PFD at 1.5m [dBW/m^2/ MHz]	PFD at 10m [dBW/m^2/ MHz]
In-band PFD	NA	-68.5	-67.3
Out-of-band PFD	$-5.0 < \Delta_F \leq 0.0$ (lower edge) $+5.0 > \Delta_F \geq 0.0$ (upper edge)	-101.5	-100.3
Out-of-band PFD	$-10.0 < \Delta_F \leq -5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)	-111.5	-110.3

Table 58: In-band and out-of-band PFD for a standard FDD UL channel (Δ_F is the frequency offset from the relevant channel edge)

TDD

A13.10 For a TDD system (assuming the 3.84 Mcps option as chosen in the transmitter emission restriction approach), there are two sets of parameters used, one for the BS and another for the MS transmitters. These are shown in Table 59 and Table 60 respectively.

Field	Value	Comments
Frequency	2.555 GHz	Consistent with proposed channel plan
Bandwidth	5 MHz	WCDMA channel
Base station maximum transmit power	27 dBm	From ECC Report 45
Base station typical transmit power	24 dBm	Typical transmit power for Urban TDD scenario from ECC Report 45 of 27 dBm less 3 dB for a 50% activation factor
Adjacent channel leakage power ratio (ACLR)	45 dB and 55 dB at a 5 MHz and 10 MHz offset from carrier frequency respectively	From 3GPP TS 25.105.
Base station peak gain	0 dBi	From ECC Report 45 Hence EIRP = 24 dBm
Base station height	10 m	Standard height.
Cell shape	Hexagon	As in figure above
Coverage radius	0.2 km	From ECC Report 45

Table 59: WCDMA TDD DL parameters

Field	Value	Comments
Frequency	2.555 GHz	Consistent with proposed channel plan
Transmit bandwidth	5 MHz	WCDMA channel
Maximum transmit power	7.6 dBm	Derived from ECC Report 45 typical power assuming 3 dB of activation factor and 3 dB of power control.
Average transmit power	1.6 dBm	From ECC Report 45
Adjacent channel leakage power ratio (ACLR)	33 dB and 43 dB at a 5 MHz and 10 MHz offset from carrier frequency respectively	From 3GPP TS 25.102
Transmit antenna height	1.5 m	Standard assumption for mobiles
Transmit peak gain	0 dBi	From ERC Report 45

		Hence EIRP = 1.6 dBm
Cell shape	Hexagon	As in figure above
Cell radius	0.2 km	From ECC Report 45
Maximum number of simultaneously active mobiles	53	From ECC Report 45

Table 60: WCDMA TDD UL parameters

A13.11 The propagation model used for the FDD DL, FDD UL and TDD cases is defined in A12.21 and the propagation parameters are listed in Table 54.

A13.12 Based on the above inputs and assumptions, the in-band and out-of-band PFD due to a standard TDD channel are given in Table 61.

Scenario	Offset from relevant channel edge [MHz]	PFD at 1.5m [dBW/m^2/ MHz]	PFD at 10m [dBW/m^2/ MHz]
In-band PFD	NA	-64.8	-63.7
Out-of-band PFD	$-5.0 < \Delta_F \leq 0.0$ (lower edge) $+5.0 > \Delta_F \geq 0.0$ (upper edge)	-102.2	-101.2
Out-of-band PFD	$-10.0 < \Delta_F \leq -5.0$ (lower edge) $+10.0 > \Delta_F \geq +5.0$ (upper edge)	-112.2	-111.2

Table 61: In-band and out-of-band PFD for a standard TDD channel (Δ_F is the frequency offset from the relevant channel edge)

PMSE

A13.13 As before, wireless cameras are assumed to be the primary PMSE usage scenario in bands where PMSE is a most likely use and in PMSE bands adjacent to the bands under consideration. The in-band and out-of-band PFD obtained for PMSE is based on this assumption.

A13.14 The assumed system parameters for wireless cameras are listed in Table 62.

Field	Value	Comments
Bandwidth	8 MHz	DVB-T standard channel width
Centre frequency	2 504 MHz	Assuming continuing across the 2 500 MHz band edge from adjacent PMSE spectrum
EIRP	0 dBW	From ECC Report 6 Note that ERC Report 38 suggested an EIRP of 6 dBW: however this was for analogue systems with a bandwidth of 20 MHz
Antenna pattern	Isotropic	From ERC Report 38

Antenna height	2 m	Assumed value ERC Report 38 suggested the antenna is typically higher than average mobile height in order to improve probability of a line of sight path to the receiver.
Separation distance	10 km	Assumed value consistent with link budget analysis below

Table 62: Wireless camera system parameters

A13.15 A basic wanted signal link budget is derived in Table 62.

Frequency (MHz)	2,500.0
Bandwidth (MHz)	8.0
EIRP (dBW)	0.0
Path distance (km)	0.5
Free space pathloss (dB)	94.4
Clutter loss (dB)	27.0
RX peak gain (dBi)	6.0
RX relative gain (dB)	-2.0
RX Noise temp (K)	1,585.0
RX signal (dBW)	-117.4
RX noise (dBW)	-127.6
C/N (dB)	10.2

Table 62: Example of wanted signal link budget

A13.16 It can be seen that at the maximum quoted range of 500 m there is an adequate C/N even with the maximum clutter loss quoted and a degree of antenna de-pointing loss.

A13.17 A worst case interference link budget is given in Table 63.

Frequency (MHz)	2,500.0
Bandwidth (MHz)	8.0
EIRP (dBW)	0.0
Path distance (km)	10.0
Free space pathloss (dB)	120.4
Smooth earth diffraction loss (dB)	19.2
RX peak gain (dBi)	6.0
RX relative gain (dB)	0.0
RX Noise temp (K)	1,585.0
RX signal (dBW)	-133.6

RX noise (dBW)	-127.6
I/N (dB)	-6.0

Table 63: Example of interfering signal link budget

A13.18 It can be seen that there is a worst case I/N = -6 dB when wireless cameras are separated by 10 km even assuming direct alignment and no other losses such as clutter. It was therefore considered that this would be a suitable separation distance to use in simulations.

A13.19 A number of OOB masks are defined in ETSI EN 300 744, in particular there is the case of a transmitter co-sited with analogue TV channels and another for critical cases where adjacent to other services (low power or receiver only). Figure 52 below shows an example of the former together with the latter.

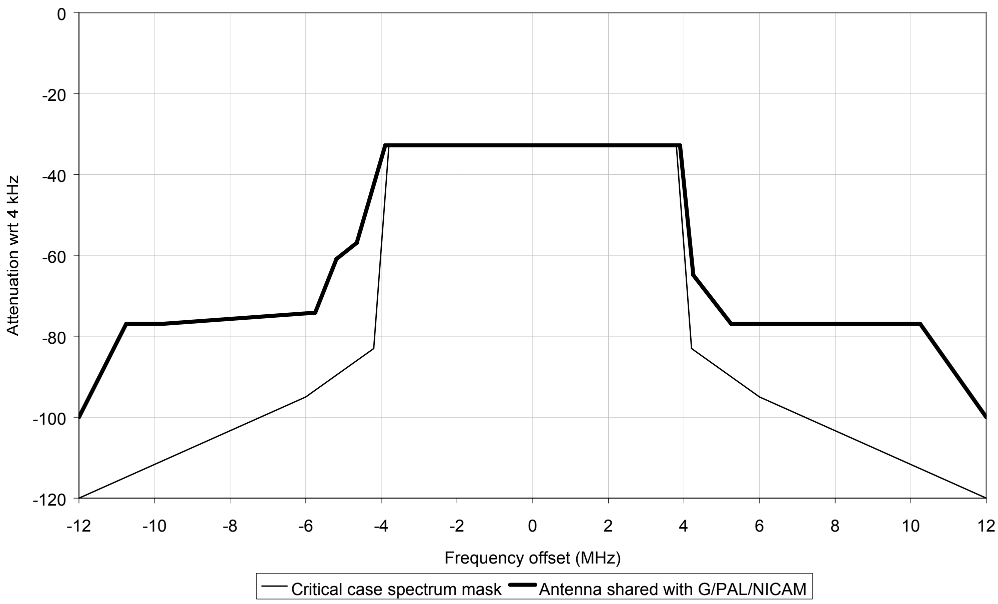


Figure 52: DVB-T masks from ETSI EN 300 744.

A13.20 To calculate the out-of-band PFD from the in-band PFD, it was considered more appropriate to use the tighter mask used for critical cases. This is because the critical case spectrum mask was also used in the analysis in ECC Report 6.

A13.21 Based on the selected spectrum mask shown in Figure 52, a relative attenuation with respect to the in-band power is calculated at regular intervals of 1 MHz. The out-of-band PFD is obtained from the in-band PFD by applying the aforementioned relative attenuation.

A13.22 The measurement area and parameters for PMSE are given by:

- Measurement area: 86.67 km^2 (The scenario was modelled assuming a grid of wireless cameras transmitting co-frequency every 10 km over the measurement area).

- Number of measurement points: 351 (these are uniformly deployed across the hexagonal central cell)

- Measurement period: ~ 1 s

A13.23 The selected propagation model is ITU-R Rec. P.452-12 using smooth Earth diffraction i.e. no terrain. This model is selected as it is valid for the frequency bands and path lengths under consideration and is able to handle the low height paths involved.

A13.24 On the other hand, ITU-R Rec. P.1546, while defined for frequencies up to 3 GHz, is generally considered less accurate than ITU-R Rec. P.452, especially for low height paths. Models such as Hata/COST 231 are typically defined for paths in the range 1 – 20 km and include significant additional clutter loss.

A13.25 An alternative approach could have been to use terrain data and move the test area to a range of locations. However according to the Consultants, previous work with DVB-T transmitters have suggested that over a large number of runs the results converge towards those for smooth Earth. A PFD mask generated assuming smooth Earth is likely to be an envelope of various masks generated using terrain and hence potentially more generic though also more relaxed. However the wide variety of events and locations that could require wireless camera support suggests that it could be appropriate to use such an approach.

A13.26 Based on the above inputs and assumptions, the in-band and out-of-band PFD due to a standard PMSE channel are given in Table 64.

Scenario	Offset from relevant channel edge [MHz]	PFD at 1.5m (*) [dBW/m^2/ MHz]	PFD at 10m [dBW/m^2/ MHz]
In-band PFD	NA	-104.8	-98.0
Out-of-band PFD	0.0	-129.9	-123.1
Out-of-band PFD	±0.2	-155.0	-148.2
Out-of-band PFD	±0.4	-156.3	-149.5
Out-of-band PFD	±0.6	-157.7	-150.9
Out-of-band PFD	±0.8	-159.0	-152.2
Out-of-band PFD	±1.0	-160.3	-153.5
Out-of-band PFD	±2.0	-167.0	-160.2
Out-of-band PFD	±3.0	-171.2	-164.4
Out-of-band PFD	±4.0	-175.3	-168.5
Out-of-band PFD	±5.0	-179.5	-172.7

Table 64: In-band and out-of-band PFD for a standard PMSE channel. (*): We assume that the PFD at 2m is the same as the PFD measured at 1.5m. (A positive frequency offset is with respect to upper channel edge and a negative offset is with respect to lower channel edge).

Mobile Satellite - Globalstar

A13.27 The Mobile Satellite – Globalstar service (downlink) occupies the 2483.5-2500 MHz band. The Globalstar system is identified as LEO-D in ITU-R Rec.M.1184 and as HIBLEO-4 in the SRS database.

A13.28 The system parameters assumed for the simulation of a constellation of Globalstar satellites are given in Table 65.

Field	Value	Comments
Orbit altitude	1,414 km	From ITU-R Rec. M.1184
Orbit inclination angle	52°	From ITU-R Rec. M.1184
Number of satellite planes	8	From ITU-R Rec. M.1184
Satellite per plane	6	From ITU-R Rec. M.1184
Offset between planes	7.5°	Assumed value to give uniform coverage
Occupied bandwidth	1.23 MHz	Designation of emission in SRS is 1M23G7W
Frequency	2 499.15 MHz	Highest frequency for this band identified in SRS
Number of satellite beams	16	From SRS using patterns T1 – T16
Gain of beams	13.8 dBi 15.8 dBi 17.8 dBi	From SRS – values for the gain for each set of rings {T1}, {T2 – T7}, {T8 – T16}
Peak power in 1 MHz	6.2 dBW 5.6 dBW 5.2 dBW	From SRS – values for the gain for each set of rings {T1}, {T2 – T7}, {T8 – T16}
Peak satellite EIRP / beam / frequency per 1 MHz	20.0 dBW 21.4 dBW 23.0 dBW	Derived from above.
Ratio of peak to average EIRP	4.5 dB	For all beams
Minimum operating elevation angle	10°	From ITU-R Rec. M.1184
Beamwidth	35° 28° 22°	Derived from peak gain assuming efficiency = 0.6
Satellite beam pattern	ITU-R Rec.S.672	Standard pattern – sidelobes of -20 dB selected based upon figure in Draft ECC Report 95

Table 65: Globalstar system parameters

A13.29 Three measurement points located in the extremities of the UK were chosen in the simulation runs.

Test Point	Latitude	Longitude
TP-1	50°N	5°W
TP-2	58°N	5°W
TP-3	51.5°N	0°E

Table 66: Measurement point locations

A13.30 The difference between the PFD at the three measurement points were less than 1.5 dB. This is to be expected in satellite systems such as Globalstar as they are designed on the isoflux principle whereby the power at the Earth's surface is kept as constant as possible in order to provide a uniform quality of service. Hence the PFD value at a single point, TP-1, was assumed to be representative of the UK.

A13.31 The simulation was run over a period of seven days of simulated time with a time step of one minute and the propagation models for space to Earth paths were assumed to be:

- ITU-R Rec.P.525: Free space path loss
- ITU-R Rec.P.676: Attenuation due to atmospheric gases

A13.32 The PFD calculated through the simulation was determined at a height of 1.5m. However, it was assumed that the in-band and out-of-band PFD of the MSS transmission at 10m are the same as at 1.5m. This is because free space path loss is likely to be the dominant factor and the difference in height is insignificant compared to the orbital distance of the satellite.

A13.33 The highest frequency specified in the downlink band in the SRS is 2 499.15 MHz. With a 1.23 MHz carrier this suggests a 0.235 MHz guard band to the edge of block at 2 500 MHz, as shown in Figure 53.

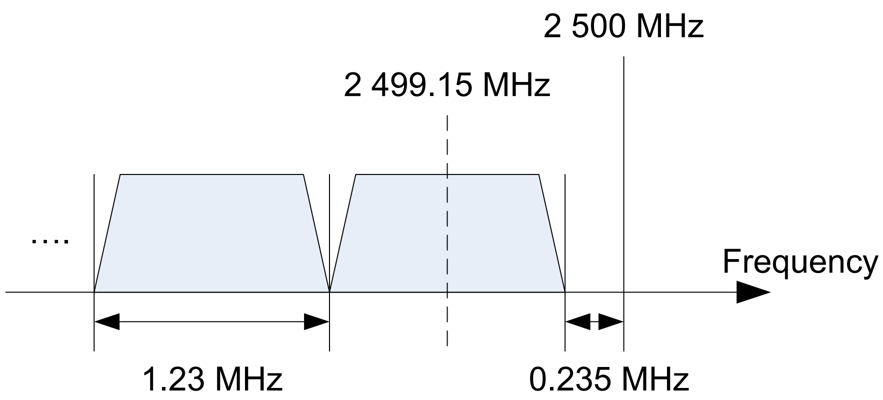


Figure 53: Arrangements of Globalstar carriers near the 2500 MHz band edge

A13.34 The out-of-band PFD is determined from the in-band PFD and the attenuation as specified by ITU-R Rec. SM.1541.

A13.35 Based on the above inputs and assumptions, the in-band PFD due to a standard Mobile Satellite – Globalstar channel is given as -113.6 dBW/m^2/ MHz and the out-of-band PFD is given in Table 67.

Offset from MSS channel edge [MHz]	Frequency (*) [MHz]	PFD [dBW/m^2/ MHz]
0.235	2500.0	-119.2
0.435	2500.2	-122.9
0.635	2500.4	-125.9
0.835	2500.6	-128.5
1.035	2500.8	-130.7
1.235	2501.0	-132.7
1.435	2501.2	-134.5
1.635	2501.4	-136.1
1.835	2501.6	-137.6
2.035	2501.8	-139.0
2.235	2502.0	-140.2
2.435	2502.2	-141.4

Table 67: Out-of-band PFD for a standard MSS channel. (*: Assuming MSS channel is centred at 2499.15 MHz)

A13.36 As it is the out-of-band emissions by the MSS services into the bottom of the 2500-2690 MHz band that are of interest, the out-of-band emissions as given in Table 67 are from an offset frequency that corresponds to the 2500 MHz band edge and thereafter at regular intervals of 200 kHz.

A13.37 The out-of-band PFD is specified at intervals of 200 kHz rather than 1 MHz as the attenuation changes significantly with frequency.

A13.38 It is assumed that the out-of-band emissions beyond 250% of the MSS channel bandwidth from the centre frequency are negligible.

Protection to MSS handsets

A13.39 While previously the out-of-band PFD generated by Globalstar satellites has been defined, in this sub-section, the maximum out-of-band PFD into the MSS channel that can be tolerated by MSS handsets is considered.

A13.40 MSS networks such as Globalstar operate with minimal margin in their link budgets. Most systems are designed to include a margin for interference of around 1 dB, which corresponds to a I/N of -6 dB, typically defined in the satellite community as DT/T = 25%.

A13.41 However this margin is the aggregate, and is apportioned using rules such as those in ITU-R Rec. S.1432. While this applies to Fixed satellite services (FSS) rather than MSS links it is useful as it documents the standard assumptions used for the design of satellite links. In particular it identifies that 1% be allocated to other sources of interference including emissions from other bands. Hence a standard out-of-band interference threshold for use with MSS handsets is DT/T = 1%, i.e. I/N

= -20 dB. According to Table 68, this corresponds to a PFD of -134.9 dBW/m^2/ MHz.

RX temp (K)	270.0
RX noise (dBW/ MHz)	-144.3
I/N threshold (dB)	-20.0
Interference limit (dBW/ MHz)	-164.3
PFD threshold (dBW/m^2/ MHz)	-134.9

Table 68: Interference thresholds

Annex 14

Glossary

2G

"Two G": second generation of mobile telephony systems using digital encoding. 2G networks support voice and limited data communications.

3G

The third generation cellular phone system, currently being deployed, which offers higher data rates than previous systems allowing services such as videophones.

AIP

Administrative incentive pricing: a fee charged to users of the spectrum to encourage them to make economically efficient use of their spectrum.

Band

A defined range of frequencies that may be allocated for a particular radio service, or shared between radio services.

CDMA

Code Division Multiple Access: A radio transmission method where individual traffic transmissions use the same frequency, but where users' traffic is separated by means of different codes.

CDMA-1x

A variant of the cdma2000 standard utilising nominal 1.25 MHz carriers.

CEPT

Conference of European Postal and Telecommunications administrations, comprising over 40 European administrations.

Communications Act

Communications Act 2003, which came into force in 2003.

Co-ordination

This term refers to the process under which users seek to come to a mutual agreement to share access to a particular range of frequencies while avoiding undue interference.

dBW

Decibels above one Watt: a logarithmic representation of radio frequency power with respect to one Watt.

ECC

Electronic Communications Committee: a committee that reports to CEPT.

EIRP

Equivalent Isotropically Radiated Power: a theoretical measure of the power radiated by a transmitter/antenna - defined as the product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna.

ERP

Effective Radiated Power: a theoretical measure of the power radiated by a transmitter/antenna - defined as the product of the power supplied to the antenna and its gain relative to a halfwave dipole in a given direction.

GHz

Gigahertz: a unit of frequency equal to 1000 million (1 x 109) MHz or cycles per second.

kHz

Kilohertz: a unit of frequency, equal to 1000 (1 x 103) MHz or cycles per second.

Liberalisation

Allowing licence holders to change the use to which they put their spectrum, within constraints to prevent interference.

Licence class

Type of licence issued by Ofcom, for example PAMR. Volume classes refer to those licence classes for which there are significant numbers of licensees, for example on site PBR with 26,000 licensees.

Licence exempt

Allowing anyone to use the spectrum for any application under certain specified restrictions, but typically with maximum power levels. The current regulations are the Wireless Telegraphy (Exemption) Regulations 2003 (SI 2003 No. 74), available at: http://www.legislation.hmso.gov.uk/si/si2003/20030074.htm

MHz

Megahertz: a unit of frequency equal to 1,000,000 (1 x 106) MHz or cycles per second.

MOD

Ministry of Defence.

Ofcom

Office of Communications. Ofcom took over the RA's responsibility for spectrum management in the UK in December 2003.

Out-of-block emissions

Emissions cause by use of the spectrum covered by a particular licence that fall immediately outside the spectrum block covered by that licence.

Partial transfer

In a spectrum trading market, licence holders may transfer only a part of the rights and obligations associated with their spectrum licence - whereby the licence can be divided (e.g. partitioned) by geography, frequency and by time.

PAMR

Public Access Mobile Radio

PMR

Private Mobile Radio

RA

The Radiocommunications Agency: a former executive agency of the Department of Trade and Industry, which was responsible for the management of most non-military spectrum in the UK and for representing the UK in relevant international bodies. The RA's functions transferred to Ofcom in December 2003.

SMO

Spectrum Management Organisation

Spectrum Framework Review (SFR)

Ofcom consultation published in November 2004 and resulting statement published in June 2005 by Ofcom on how spectrum will be managed in the future.

Spectrum Framework Review: Implementation Plan (SFR:IP)

Ofcom consultation published in January 2005 by Ofcom on the release of spectrum in 2005 – 08, and on extending spectrum liberalisation and trading to mobile services.

Spectrum mask

A way of specifying the amount of power that a transmitter is allowed to transmit into neighbouring frequency channels.

Spectrum trading

Process through which spectrum licence holders are able to transfer some or all of their rights to a third party.

TETRA

A digital two-way radio standard developed by the European Telecommunications Standards Institute (ETSI)

TETRAPOL

A digital PMR technology

Trading Regulations

The Statutory Regulations that facilitate spectrum trading.

Undue interference

Interference in relation to any wireless telegraphy which is undue and also harmful (as described in section 19(5) and (5A) of the Wireless Telegraphy Act 1949). In summary this includes interference that creates dangers or risks of dangers to the functioning of any radiocommunications service designed for the purposes of navigation or safety services, or if the interference degrades, obstructs or repeatedly interrupts authorised broadcasting or other wireless telegraphy.

Wireless telegraphy

The means of sending information without the use of a wired system.

Wireless telegraphy licences

Licences issued under the Wireless Telegraphy Act 1949 (as amended).

WT Acts

Wireless Telegraphy Act 1949 and Wireless Telegraphy Act 1998 (both as amended)