OFFICE OF COMMUNICATIONS

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

This document sets out Ofcom's decisions for the award of wireless telegraphy licences in these spectrum bands. The Information Memorandum for this award is published separately.

Statement

Publication date: 4 April 2008

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Section 1

Executive Summary

1.1 This Statement sets out our decisions on the award of the frequency bands 2500-2690 MHz (the 2.6 GHz band) and 2010-2025 MHz (the 2010 MHz band). It explains that we have decided to proceed with the award and why we have decided to do so as soon as possible, and it explains the way in which the award will be structured and the conditions that will attach to the licences to be awarded.

1.2 The 2.6 GHz band offers an important opportunity for the development of mobile broadband services in the UK, across Europe and in a number of other countries worldwide. With 190 MHz of spectrum available, it is the largest single release of spectrum suitable for mobile use to take place for a significant period of time.

1.3 The 2010 MHz band could support similar services and, as it is a potential substitute for the 2.6 GHz band for some applications, we are making it available as part of the same award process as the 2.6 GHz band.

1.4 We consulted on outline principles for the award of the 2.6 GHz and 2010 MHz bands when we set out our plan for a programme of spectrum awards (in the SFR:IP in January 2005). We started detailed work on this award in 2006, inviting stakeholders to submit evidence and views to our independent advisers in preparation for the publication of detailed consultation proposals. We developed and refined our proposals on the award - in terms of our general approach, the technical and non-technical licence conditions and the auction rules – through three consultations (in December 2006, August 2007 and December 2007) and a series of seminars and meetings with interested parties. Throughout this process, we have participated actively in European discussions on use of the band, in CEPT and EU regulatory groups, with the European Commission, industry members and other Member States.

1.5 Alongside this Statement we are also publishing:

- a notice of our proposal to make four statutory instruments comprising the draft regulations and order which will give effect to our policy decisions for the award; and

- an Information Memorandum which sets out relevant information to help parties interested in participating make their own decisions in respect of the award.

Decision on award timing

1.6 In making decisions in relation to this award, we have given careful consideration to the duties imposed on us by both the European legislative framework and by UK legislation. Taking into account the relevant facts and circumstances, we consider that our principal duty under the Communications Act 2003 to further the interests of consumers, where appropriate by promoting competition, is of particular importance to this award. In fulfilling this duty, we consider that our duties to secure optimal use of spectrum, promote innovation, and secure the availability of a wide range of electronic communications services are also of particular significance.

1.7 We consider that a decision to hold an award for the 2.6GHz and the 2010MHz bands, and to do so as soon as possible, is the decision that best meets these duties. It is our usual practice to make spectrum which is not being used available to the market and all stakeholders have agreed that we should do so in this case. Further, on 2 April 2008 the Radio Spectrum Committee of the European Commission (RSC) unanimously agreed the text of a decision on harmonised use of the 2.6GHz band ("the RSC Decision"). The RSC Decision requires Members States to designate the 2.6 GHz band within 6 months of the decision's entry into force and subsequently make it available on a non-exclusive basis for terrestrial systems capable of providing electronic communications services, subject to a number of technical parameters relating to harmful interference. The recitals to the RSC Decision state that the results of the technical work undertaken by CEPT which form the basis of the technical parameters of the RSC Decision should be made applicable in the Community and implemented by Member States without delay. It is anticipated that the decision will come into force in early June 2008. The requirements on Member States set out in the RSC Decision confirm our initial view that we should make the 2.6GHz band available, and that we should do so as soon as possible.

1.8 Notwithstanding our obligations under the recent RSC Decision, stakeholders had different views on the timing of the award in their responses to our consultations, and so our further reasoning as to why we consider that we should proceed with the award as soon as possible (in addition to our obligations under the RSC Decision) is summarised below.

1.9 The 2.6 GHz band and the 2010 MHz band constitute a significant amount of spectrum. Given its bandwidth and propagation characteristics, the 2.6 GHz band in particular is a highly valuable spectrum band which is suitable for a wide range of uses including current and developing services to provide high speed mobile broadband services. The 2.6 GHz and 2010 MHz bands are both available for new uses. The 2.6 GHz band is largely unused after current PMSE users were notified in 2002 that they would have to vacate the band for its award, and the 2010 MHz band is currently unused. We consider that our duty to secure optimal use of spectrum means here that we should seek to award the available spectrum to enable use as soon as possible unless there are strong countervailing reasons not to do so.

1.10 As a result of its availability for mobile services in the EU and a number of countries worldwide the 2.6 GHz band provides an important opportunity for the introduction of next generation mobile technologies as well as for the provision of additional capacity for networks using the current generation of technologies. There are two main competing technologies for the provision of mobile services at 2.6 GHz:

a) WiMAX, developed with a strong input from the internet and IT sectors, which is optimised for data services (with voice over IP being one of the potential data applications) and for which equipment is ready and available now for operation in unpaired (TDD) mode; and

b) 3G mobile technologies which are in use now in the UK and, significantly, their likely successor technologies based on the LTE standard which is also optimised for data and is primarily based on paired (FDD) operation. LTE equipment is likely to be available in the relatively near term, probably around 2010 or possibly before, as standardisation groups and manufacturers accelerate LTE development at least in part in response to the competitive threat from WiMAX.

1.11 Use of the 2.6 GHz band offers significant scope for innovation, with the potential for new technologies, services, applications and devices. It also offers scope for new competition as most parties who have expressed an interest in using the band as soon as possible for mobile WiMAX would be new providers of wireless services in the UK. Allowing use of the spectrum is likely to generate significant consumer benefits through increased competition and innovation and help secure a wide range of electronic communications services in the UK. By contrast, delaying the award would be likely to reduce those benefits as the 2.6 GHz band would not be put to use until a later date. Our analysis suggests that there is a time-limited window of opportunity for new mobile providers to establish services using mobile WiMAX. No other spectrum is currently available (or as suitable) for the provision of mobile WiMAX-based services. The opportunity for new service providers to develop and establish mobile broadband services is likely to depend in part on their ability to offer differentiated services in a market environment which already contains a number of existing providers of data services and in which other next generation mobile technologies (such as LTE) are not yet available.

1.12 We therefore consider that the window of opportunity for services using new technologies such as mobile WiMAX is relatively short and a material delay to the holding of this award would run a serious risk that those services may either fail viably to establish themselves, or may not be developed at all. This would run a serious risk that significant potential consumer benefits in the form of increased competition through new technologies and services would be forgone.

1.13 Throughout our consultation process, a number of organisations have expressed a strong interest in accessing the 2.6 GHz band and developing mobile broadband services at the earliest opportunity using mobile WiMAX.

1.14 The nature of the responses we have received on the issue of timing reflects the interests of the stakeholder groups concerned. One group of stakeholders, including those interested in the deployment of WiMAX-based services in the UK, has strongly supported the proposal to hold the award as soon as possible. Another group, including most of the five existing MNOs, has argued strongly for delay.

1.15 Within this second group, some respondents, comprising mainly most existing MNOs, have argued that to proceed with an award now would risk an inefficient outcome and would discriminate against them as they face more significant uncertainties than other potential participants in the award. In particular they argue that the 2.6 GHz award should be delayed in order to await the resolution of uncertainties surrounding the liberalisation of 2G spectrum (which they claim would increase the efficiency of the award and remove a source of alleged discrimination against them). Some uncertainties about the future use of 2G spectrum will remain until such time as the liberalisation of the 2G spectrum has been completed and, if we decide that some existing 2G spectrum holdings needed to be released as part of this process, until such time as any award of the released spectrum had been held. The significant differences in the MNO responses to our proposals of September 2007 on the liberalisation of 2G spectrum mean that decisions as part of this process are themselves unlikely to be made imminently. It is therefore likely that a delay to this award for this reason would be for at least a year, and probably longer. Such a delay would incur a material cost in terms of forgone competition and innovation benefits, delay to efficient use of the 2.6 GHz band, and would risk foreclosure of the window of opportunity for WiMAX-based new entry.

1.16 In any event, we consider that the scope for any meaningful substitutability between 2.6 GHz and 2G spectrum is limited to a specific set of scenarios (mainly relating to

the future development of LTE) which themselves are subject to uncertainty about availability of equipment in particular bands (in terms of timing and performance). Further, we consider that other uncertainties relating to a wide range of market, technology and regulatory conditions are likely to have a greater influence, in aggregate, on valuations of 2.6 GHz spectrum.

1.17 Uncertainty is part of the normal course of business and, as a rule, we consider that the market will manage these uncertainties more effectively than the regulator. Market participants are much better placed to determine the precise value and risks to them associated with the award of available spectrum. In addition, to the extent that the 2.6 GHz award results in a spectrum allocation that turns out not to support its highest value use in future, then spectrum trading provides significant scope for this outcome to be mitigated.

1.18 We acknowledge that different stakeholders are in different positions, and as such it is inevitable that they will not all be affected in the same way by our decision. We have conducted a thorough analysis of the benefits and costs of our proposal to proceed to award the spectrum now, and have concluded that the benefits of proceeding now considerably outweigh the potential costs. We do not consider that the effect of our decision to proceed as soon as possible unduly discriminates against any stakeholders.

1.19 We have also considered whether proceeding now with an award of part of the band (as proposed by one respondent) would be as capable of fulfilling our duties and objectives as an award of the whole band would. We have concluded that an award of part of the band would not be capable of similarly fulfilling our statutory duties as an award of the whole band would, and that as such our approach is a proportionate means of fulfilling out statutory duties and objectives.

1.20 In light of the above considerations, and our obligations under the RSC Decision, we have decided to proceed with the award of the 2.6 GHz band in its entirety as soon as possible and this is likely to:

- promote competition in the provision of mobile services, through likely new entry and the deployment of new technologies to compete with existing technologies, to the overall benefit of consumers;
- promote both technology and service innovation and widen the range of services available to consumers; and
- secure optimal use of an important spectrum band.

Method of awarding the spectrum

1.21 In order to achieve our objectives for the award, and in line with the RSC Decision (as applicable), we have also decided:

- to award the rights to use the 2.6 GHz and 2010 MHz bands by auction, as part of a single process so that parties who value spectrum the most can access it;
- to do so in a flexible award, which allows the market to determine how the band is used between the two main types of use (paired and unpaired), so that the market rather than the regulator can determine how competing technologies should access spectrum, as it is necessarily unclear in advance of the award what the optimal balance would be;

- to facilitate market-led harmonisation by providing a framework for flexibility that is consistent with likely uses internationally and in Europe in particular (namely paired use based on 120 MHz duplex spacing, a minimum portion for unpaired use of 50 MHz at 2570-2620 MHz, and blocks of 5 MHz for spectrum packaging);

- to define conditions of use which allow efficient coexistence of users of the bands and enable harmonisation benefits and economies of scales; and

- to design the auction carefully so as to maximise scope for efficient use and to promote competition by enabling participants a fair chance to win rights on the basis of their valuations and by limiting as much as possible the scope for strategic behaviour.

1.22 We elaborate on these points below.

Licence conditions designed to secure optimal use of the resource

1.23 We have made decisions on all aspects of the non-technical licence conditions (technology and service neutrality, tradability, duration and whether to include roll-out obligations) and technical licence conditions (power limits designed to manage the risk of interference between spectrum users). These licence conditions are designed to secure optimal use of the spectrum, promote competition and maximise the scope for consumer benefits by providing flexibility to the market in deciding how to use spectrum whilst managing the risk of interference.

Non-technical licence conditions

1.24 We have decided to award licences for use of the 2.6 GHz and 2010 MHz band on a technology and service neutral basis. This is consistent with our general UK and EC duties, and with our policy to secure optimal use of the spectrum by only including restrictions that are necessary, by allowing licensees the freedom to respond to market circumstances, and to make their own decisions about which technologies to use and which services to provide (while safeguarding the risk of interference). This enables market-led harmonisation and is consistent with realising the benefits of pan-European services. This approach is also consistent with the recent European Commission Recommendation on licence conditions, developed by COCOM, of which we are required to take the utmost account.

1.25 The licences for the 2.6 GHz and 2010 MHz bands will be tradable in order to increase the scope for optimal use of the spectrum after the award and to remove the need for complex regulatory intervention if licensees want to change their holdings.

1.26 The licences for use of these bands will be indefinite in duration, with an initial period of 20 years during which Ofcom cannot revoke a licence for spectrum management reasons. After that initial period of 20 years, we will have the power to revoke a licence for spectrum management reasons and we may apply Administered Incentive Pricing depending on conditions at the time. This is designed to give appropriate conditions of tenure for licensees to recover their investment, develop services and promote market-based principles for spectrum management.

1.27 We have decided not to include a condition in the licences requiring licensees to roll-out services across a specified percentage of the UK. We are under no statutory obligation to include such a condition and we do not consider that there is a clear policy or regulatory reason for us to include one. Conversely, we consider that to include a roll-out obligation would create a material risk of deterring entry and thereby

reducing benefits for consumers. Moreover, such an obligation would be hard to implement with licences that are tradable and technology neutral. We are satisfied that the decision not to include a roll-out obligation in the 2.6GHz and 2010MHz licences will not discriminate against parties whose licences at 2.1GHz include roll-out obligations, nor will it lead to a distortion of competition, as some of the existing MNOs have argued. We consider that our decision not to include a roll-out obligation will instead promote competition and innovation.

Technical licence conditions for use of the two bands

1.28 The technical conditions for use of these bands have been subject to extensive consultation and analysis, both as part of our own consultation process and also within the context of European regulatory discussions in the CEPT project team SE42 which was charged, under the WAPECS mandate from the EC, with developing the least restrictive technical conditions for use of these bands across Europe.

1.29 The technical conditions that will attach to the licences issued for use of the 2.6 GHz band in the UK will take the form of Block Edge Masks which are the same as those set out in CEPT Report 19 (which captures the output of project team SE42). They are also consistent with the RSC Decision agreed on 2 April 2008 in relation to the 2.6 GHz band and are designed to be the least restrictive conditions possible whilst managing the risk of harmful interference between spectrum users. The final technical conditions incorporate some changes from the conditions on which we consulted in the Discussion Document, notably a tighter out-of-band mask of -45dBm/MHz EIRP where appropriate, in order to mitigate the risk of interference across adjacent users within the 2.6 GHz band. We have also included some additional provisions relating to the use of relaxed out-of-band masks for blocks of spectrum whose in-block power limit is restricted.

1.30 We have also decided to tighten (in most cases to -45dBm/MHz EIRP) and extend (to ±30 MHz) the out-of-band emission limits so as to reduce the scope for interference into the following adjacent users:

- PMSE users below 2500 MHz and above 2025 MHz;
- radar users above 2700 MHz; and
- prospective future operators of networks of base stations, referred to as Complementary Ground Components, below 2010 MHz (complementary to Mobile Satellite Systems operating in the 1980-2010 MHz range).

1.31 In the first two cases, the changes will provide a greater degree of protection to the adjacent users without any material adverse impact on operators in the 2.6 GHz band (either in terms of their ability to use the spectrum effectively or in terms of the costs of doing so). In the third case, the revised out-of-band emission limit below 2010 MHz may reduce the ability of an operator to use the lowest 5 MHz of the 2010-2025 MHz band. We have made this change taking account of our legal obligation to comply with the EC Decision on Mobile Satellite Services adopted in February 2007.

Market-led harmonisation –interference environment and packaging for the 2.6 GHz band

1.32 There are two main types of likely uses for the 2.6 GHz band, reflecting technologies that are available or in advanced stages of development:

- paired use for FDD technologies which rely on paired blocks of frequencies separated by 120 MHz, one for network base station transmission (and user equipment reception), the other for user equipment transmission (and network base station reception). The two main FDD technologies relevant to 2.6 GHz are LTE and possibly UMTS and its evolutions such as HSPA;

- unpaired use for TDD technologies which rely on unpaired blocks in which network base stations and user equipment both receive and transmit at the same frequency, but in different timeslots. The main TDD technology relevant to 2.6 GHz is mobile WiMAX.

1.33 As indicated above, we have decided that the award should be structured so as to allow the market to determine how the band is used as between these two main types of use (paired and unpaired). In this way the market, rather than the regulator, can determine how competing technologies should access spectrum, as it is necessarily unclear in advance of the award what the optimal balance will be.

1.34 Establishing technical conditions that will manage the risk of interference whilst maximising the flexibility over how the spectrum can be used has been central to our decision making process. We have consulted extensively, and carried out substantial analysis, on a wide range of factors relating to the interference environment within the 2.6 GHz band itself as well as the interference environment relating to the coexistence with international use and with users adjacent to the 2.6 GHz and 2010 MHz bands.

1.35 Key amongst our concerns, and amongst the concerns of stakeholders, has been the need to manage the risks of interference between base stations operating adjacent to the boundaries between different users within the 2.6 GHz band, and the risks of interference between TDD terminals and FDD terminals operating within the 2.6 GHz band. In respect of the interference environment within the 2.6 GHz band, we have reached the following conclusions.

- A 5 MHz restricted block at the boundary between FDD and TDD systems, and at the boundary between unsynchronised TDD systems, will be necessary and sufficient to manage the effects of base station to base station interference. Better transmit and receive filtering (by comparison with the minimum requirements in current 3GPP specifications) are likely to be required on base stations in blocks immediately adjacent to the boundaries; but this is technically feasible and should not add materially to the cost of base station deployment.

- The impact on performance of terminal-to-terminal (mobile-to-mobile) interference should be minimal; indeed, the more detailed analysis that we have carried out indicates that this should be even less of a concern than we previously indicated in the Discussion Document, even in so-called “hot-spot” situations. Accordingly, there should be no material diminution of performance for users of paired (FDD) spectrum if the 2.6 GHz award leads to an outcome in which TDD terminals are used in the upper part of the 2.6 GHz band.

1.36 These conclusions have a number of implications for our approach to packaging of the 2.6 GHz spectrum for award.

- There are no technical reasons that prevent us from adopting a flexible approach as regards the division of the band between paired and unpaired use. In particular, there is no need to constrain the award outcome to the CEPT (05)05 band-plan. Nor is there a need to place constraints on the way in which particular

technologies may be deployed (such as requiring any WiMAX systems to be deployed in a half-duplex FDD mode outside of the central 50 MHz).

- The adoption of a 5 MHz block width, a 120 MHz duplex spacing for FDD systems, and the identification of FDD uplink and downlink parts in the 2.6 GHz band, and the consistency of the technical conditions that we have adopted with those included in the CEPT 19 report, will be sufficient to allow operators to access the benefits of market-led harmonisation in that they will support a Europe-wide marketplace for equipment (base stations and handsets) and facilitate international roaming of handsets and other user equipment in Europe and other regions.

1.37 In reviewing the 2.6 GHz in-band interference environment we have used the technical conditions relating to block edge masks proposed in CEPT Report 19, based on the output of CEPT project team SE42. In doing so, we have taken full account of European regulatory work as requested by a number of stakeholders who were concerned about in-band interference issues.

1.38 As noted above, we have tightened and extended the masks on emissions that licensees can produce outside of the 2.6 GHz and 2010 MHz bands. We have also analysed the potential for interference from adjacent users into the 2.6 GHz band itself, drawing on empirical measurements on the potential impact of radar transmissions centred above 2700 MHz. This analysis indicates that there should be no material adverse impact on the ability of future operators to make use of the 2.6 GHz band.

1.39 Since the Discussion Document we have also concluded a Memorandum of Understanding (MoU) with each of Ireland and France that set out arrangements for coordination of use of the 2.6 GHz band. These provide sensible arrangements for future 2.6 GHz operators in neighbouring countries to coordinate their operations near to the relevant borders. These MoUs are included in the Information Memorandum published alongside this Statement.

1.40 A further key issue on spectrum packaging relates to the viability of using an auction design based on generic lots within the 2.6 GHz band. Our technical analysis indicates that there is no reason why the in-band interference environment, the interference environment with adjacent users, or the need for coexistence with international uses, should cause one frequency block to have a materially different utility or value to any other frequency block in the same category (either paired or unpaired). Accordingly, we have concluded that there is no reason why an auction design based on the use of generic lots should be at risk of being inefficient on account of technical interference considerations.

1.41 In light of the above conclusions we have decided that the spectrum for award in the 2.6 GHz band will be packaged as follows.

Specification of lots

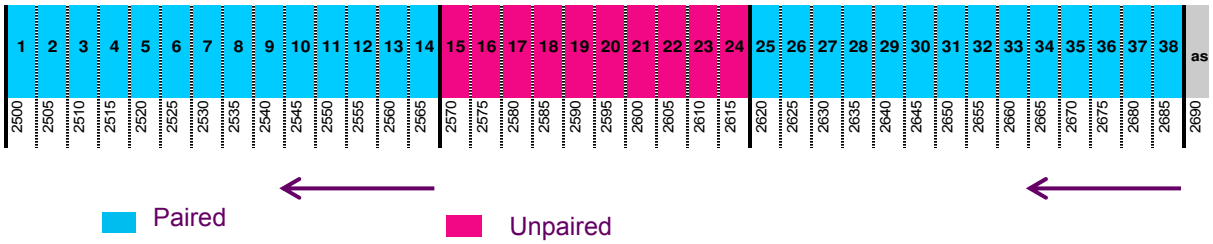
- Spectrum will be made available in the form of individual unpaired (TDD) lots of 5 MHz and in the form of paired (FDD) lots of 2x5 MHz, each of which can be aggregated to form larger channel widths; subject to the points below on adjacencies, these lots will represent standard blocks with technical conditions that allow base stations to transmit at full power.

- The spectrum for paired lots will be split into uplink and downlink frequencies separated by a 120 MHz duplex spacing with the uplink in the lower portion (2500-2570 MHz) and downlink in the upper portion (2620-2690 MHz).

Flexibility

- The award outcome will include a maximum of 2 x 70 MHz of paired spectrum and a minimum of 50 MHz of unpaired spectrum available in the range 2570-2620 MHz between the paired uplink and downlink frequencies.

Figure 1: 2.6 GHz band-plan with labelling of blocks #1 to #38 showing paired and unpaired spectrum as per the CEPT band plan. Arrows indicate how unpaired spectrum can increase over the minimum of 50 MHz

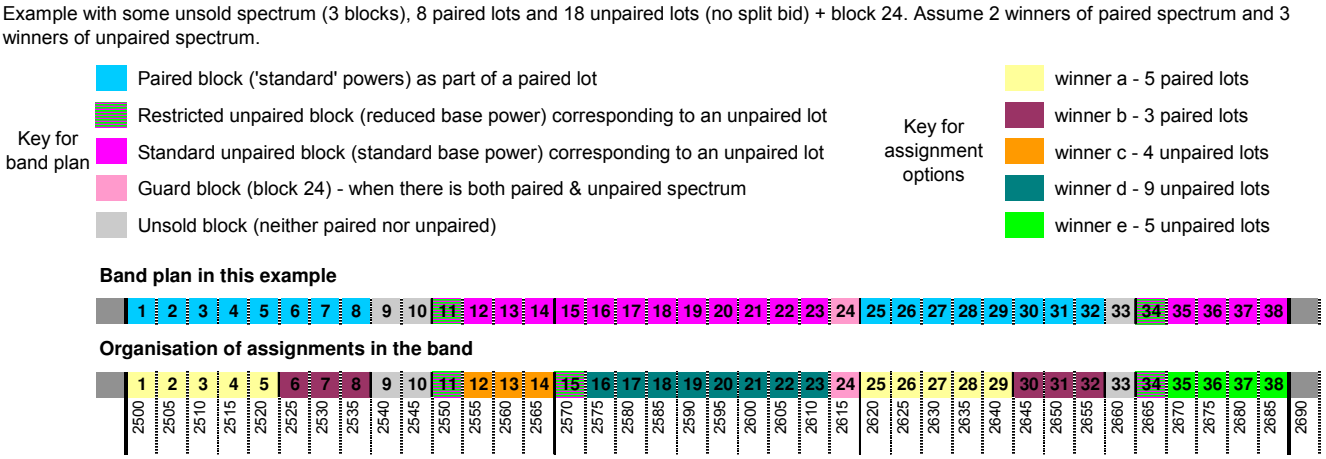


- Within the above limits, there will be flexibility over allocation of spectrum as between paired and unpaired assignments. This allocation will be determined by the demand for each type of lot that is revealed through the auction process. If this leads to an allocation of unpaired lots which exceeds the number of lots available in the central 50 MHz of the CEPT band plan of ECC Decision (05)05, then this will be achieved by converting the upper portions of the paired uplink and downlink frequencies in equal parts to unpaired use (i.e. from 2570 MHz / block #14 and 2690 MHz / block #38 downwards).

Adjacencies

- At all adjacencies between paired and unpaired assignments, and between unpaired assignments there will be a 5 MHz restricted block as part of the unpaired spectrum, with more limited transmission rights and for which the risk of receiving interference from neighbouring assignments may be greater. This means that the lower 5 MHz block of all unpaired assignments will take the form of a restricted block. This also means that block #24 will automatically be a restricted block provided that block #25 is assigned for paired use. This is illustrated by an example in Figure 2 below.

Figure 2: Illustration of award outcome showing the position of paired and unpaired lots, including restricted unpaired blocks, where there is more unpaired spectrum than the minimum in the CEPT band plan



1.42 The spectrum available for award in the 2010 MHz band will be packaged as a single lot covering the frequencies from 2010 MHz to 2025 MHz.

Auction design

1.43 We have decided on an auction design for the award of the 2.6 GHz and 2010 MHz bands that is based on:

- the use of generic lots for the 2.6 GHz spectrum. In particular, the auction will use two categories of generic lots in the 2.6 GHz band - paired lots of 2x5 MHz unpaired lots of 5 MHz in the 2.6 GHz band. Together with the single 2010 MHz lot, there will therefore be three categories of lot;

- a division of the auction into two main stages-

  - a Principal Stage in which generic paired lots and generic unpaired lots in the 2.6 GHz band, together with the 2010 MHz lot, are awarded to winning bidders; and

  - an Assignment Stage in which the generic paired and unpaired lots in the 2.6 GHz band which are won in the Principal Stage are converted into specific frequency assignments.

1.44 This approach provides the most efficient way of allowing bidder demand to determine how much spectrum will be paired spectrum and how much spectrum will be unpaired spectrum in the 2.6 GHz band, at the same time as determining which bidders win how much of each type of spectrum. As such, this auction design most effectively meets a key objective for this award which is to promote an outcome that awards spectrum to those that are most likely to create greatest value from its use, irrespective of technology or type of use. The choice of this design relies on there not being large differences in the value of spectrum at different frequencies within one category of generic lot. As noted above, our technical analysis shows that the interference environment should not create a material differential in utility or value of any one frequency block as compared with any other.

1.45 The Principal Stage is further divided between:

- the primary bid rounds where bidders indicate their preferred package of lots at a given price level for each category of lot, and the prices of each category of lot are increased between rounds until there is no excess demand (this is referred to as a combinatorial clock format); and

- a subsequent supplementary bids round where bidders can submit sealed bids for other packages that differ (in terms of bid value and / or the composition of the package) from those submitted during the course of the primary bid rounds.

1.46 The primary and supplementary round bids, taken together, allow bidders to express their preferences for all combinations of lots which they would be happy to win and, in so doing, maximise the scope for an efficient outcome to the award. An important role of the primary bid rounds is to support price discovery and enable a reduction in common value uncertainty as bidders can observe the way in which aggregate demand decreases from round to round as the clock prices increase.

1.47 The outcome of the Principal Stage (in terms of which bidders are successful, how many lots of each category they win, and the consequential split between paired and unpaired lots) is derived by selecting the highest value combination out of all primary and supplementary package bids, subject to the constraints for organising paired and unpaired spectrum in the band.

1.48 The Assignment Stage is conducted via a single round of sealed bids. Those bidders who win generic lots in the 2.6 GHz band in the Principal Stage have the opportunity to indicate the value that they attach to the specific frequencies at which these generic lots could be assigned (and if they are indifferent to the choice of frequency then they can submit bids of zero value).

1.49 In both the Principal Stage and the Assignment Stage, the prices paid by the winning bidders follow the principle of a “second price rule” whereby the prices paid are set no higher than the level needed to ensure that no other coalition of bidders would have been prepared to pay more to win the spectrum (in the Principal Stage) or to receive the specific frequency assignments (in the Assignment Stage). The licence fee that each winning bidder must pay for the spectrum is the sum of the base price determined in the Principal Stage and the additional price determined in the Assignment Stage.

1.50 In developing this auction design we have, together with our independent specialist advisors on auction design, conducted a series of mock auctions using this design. We have also carried out a review of the award of spectrum at 10 GHz, 28 GHz, 32 GHz and 40 GHz (the 10-40 GHz auction) which used a similar auction design and which we completed in February 2008. As part of this review process we have concluded that a combinatorial clock approach is effective at delivering the flexible approach to use of the 2.6 GHz band and that it reduces the complexity for bidders and reduces the scope for strategic behaviour compared to other auction formats.

Auction rules and procedures

1.51 In designing the detailed rules for the award, we have included provisions intended to ensure the efficiency of the process, encourage bidding in accordance with valuations and reduce the scope for strategic behaviour. These provisions include:

- low reserve prices to promote participation (while still deterring frivolous bidders);

- a requirement that bidders either maintain or reduce their demand from one round to the next during the primary bid rounds (using an eligibility point rule);

- an information policy in which we release information on aggregate demand by category of lot only in each primary bid round. This is the essential information required to support price discovery. Releasing more information would carry the risk of enabling strategic behaviour that could restrict competition.

Award process

1.52 As with other recent awards that we have conducted, the auction itself will comprise four distinct stages in the award process which are as follows:

- the application stage, in which interested parties apply to take part in the auction process;

- the qualification stage, in which we determine which applicants are eligible to participate in the auction process;

- the auction stage which, as explained above consists of the Principal Stage, made up of the primary bid rounds and supplementary bids round, and the Assignment Stage; and

- the grant stage, in which we grant licences to those bidders who have been successful in the auction stage.

Conditions relating to individual bidders

1.53 We have concluded that there is no objective justification for treating particular bidders, or classes of bidder, in a different way to other bidders, or classes of bidder.

1.54 In light of the expressions of interest which we have received, we expect the award of the 2.6 GHz and 2010 MHz bands to be competitive. However, in order to prevent a low probability outcome (where only one bidder wins the majority of the spectrum) with significant potential consequences for the scope for competition and innovation, we have decided to apply a 'safeguard' cap to the amount of spectrum which any one bidder in the award can win. We have set the cap at 80 MHz of standard spectrum (i.e. excluding restricted blocks).

1.55 Finally, we have decided to allow parties who are associated with more than one applicant to apply in certain circumstances to be excluded from one or more applicant or bidder groups subject to submitting suitable warranties and undertakings. All such applications will be subject to approval by Ofcom, and will be assessed on a case by case basis. The mechanism for exclusion from an applicant or bidder group is designed to maximise the scope for legitimate participation in the auction while preserving the integrity of the award process.

Next steps

1.56 We are publishing a notice of our proposal to make four statutory instruments in relation to the award process. These draft statutory instruments comprise the Draft Auction Regulations, draft regulations amending existing wireless telegraphy trading and register regulations, and a draft order limiting the number of licences to be awarded for the bands in this process.

1.57 The draft statutory instruments are subject to a statutory consultation that closes on 6 May 2008.

1.58 We plan to hold a seminar in April to present our decisions for the award process and the draft regulations. This will include a demonstration of the auction software and an invitation for interested parties to take part in a mock auction process after the seminar.

1.59 After considering the responses to the statutory consultation and incorporating any necessary amendments, we expect to make the regulations for this award in May or June. The regulations will then come into force in June or July and we expect to start the award process by inviting applications in July, at least two weeks after the entry into force of the regulations.

1.60 We expect to start the primary bid rounds in September.

Section 2

Introduction

2.1 This Statement sets out the decisions we have made for the award of wireless telegraphy licences for the use of the 2500–2690 MHz band (the "2.6 GHz band") and the 2010–2025 MHz band (the "2010 MHz band"). These decisions will be given effect to by statutory instruments.

2.2 Alongside this Statement we are publishing the following documents.[1]

- An Information Memorandum - this sets out relevant information that interested parties should take into account when considering their possible participation in the award process.

- A notice of our proposal to make four statutory instruments in relation to the award process in accordance with section 122 of the Wireless Telegraphy Act 2006. These statutory instruments include the auction regulations (the Draft Auction Regulations), regulations extending spectrum trading to the band, regulations to allow for publication of the identity of licensees and terms of the licences in the band and an order limiting the number of licences in the band. The statutory consultation period for these instruments expires on 6 May 2008.

2.3 We also expect to publish later in April two further documents which provide supporting information for some of the technical analysis summarised in Section 5 of this Statement:

- a technical report on the risk of interference between user terminals in the 2.6 GHz band;

- a technical report by ERA Ltd on measurements of the technical characteristics of 3G terminals (handsets) which are now commercially available and operate in the 2.1 GHz band.

Background to the award

2.4 In 2003, the Radiocommunications Agency (RA) consulted on the 2.6 GHz band[2]. The purpose of this consultation was to seek views on the approach the UK should adopt in CEPT[3] discussions for the development of deliverables by the Electronic Communications Committee of the CEPT (ECC) relevant to the band. In particular, the RA consulted on the most appropriate spectrum arrangements and associated issues. We subsequently issued a short statement[4] which highlighted our view that we 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

[1] These documents are available at http://www.ofcom.org.uk/radiocomms/spectrumawards/ and at http://www.ofcom.org.uk/consult/condocs/2ghzrules/.
[2] http://www.ofcom.org.uk/static/archive/ra/topics/pmc/consult/2-5ghzcondocfinal.doc
[3] European Conference of Postal and Telecommunications Administrations, which includes the Electronic Communications Committee (ECC). See http://www.cept.org/.
[4] http://www.ofcom.org.uk/consult/condocs/3g_2500_2690_consultation/

solutions to decide the optimal use of the spectrum for terrestrial applications. We then took part in discussions in CEPT on that basis.

2.5 In January 2005, we consulted on the Spectrum Framework Review: Implementation Plan[5] (SFR:IP) in which we outlined preliminary proposals for the award of the 2.6 GHz and 2010 MHz bands. In the SFR:IP, we proposed that the spectrum bands should be awarded on a technology neutral basis.

2.6 In July 2005, we published the SFR:IP Interim Statement.[6] This set out our intention to move forward with proposals for the award of technology neutral licences for both 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.

2.7 Since publication of the SFR:IP Interim Statement, we have engaged extensively with stakeholders in order to prepare our decisions for the award of the 2.6 GHz and 2010 MHz bands.

2.8 We published three further consultations on the award:

- in December 2006, a consultation covering the general policy for the award (the December 2006 Consultation);
- in August 2007, a discussion document (the Discussion Document) providing updated proposals in response to a range of comments made in responses to the December 2006 Consultation; and
- in December 2007, a consultation on updated proposals for the auction design and rules and a first draft of the statutory instrument setting out the award process (the Auction Rules Consultation).

2.9 We also held several seminars[7] to prepare consultations and to explain our proposals:

i) in May 2006, we invited inputs to our independent advisers' work and sought comments in preparation for the December 2006 Consultation;

ii) in February 2007, we presented our proposals of December 2006;

iii) in September 2007, we presented our proposals of August 2007; and

iv) in November 2007, we set out our provisional thoughts and invited further feedback on auction rules and design in order to prepare the Auction Rules Consultation.

2.10 Throughout this process, we have also had discussions with a range of interested parties in the UK, to clarify our understanding of the circumstances relevant to the award, in particular with existing adjacent users (for example CAA, MoD, JFMG and PMSE users) and with parties who expressed an interest in using the available bands. As an active participant in European regulatory discussions, we have also

[5] http://www.ofcom.org.uk/consult/condocs/sfrip/
[6] http://www.ofcom.org.uk/consult/condocs/sfrip/
[7] The presentation slides for each event are available at http://www.ofcom.org.uk/radiocomms/spectrumawards/awardspending/award_2010/.

been discussing use of the 2.6 GHz and 2010 MHz band in detail in a number of working groups of CEPT and of the European Community, with a range of stakeholders and other European regulators. We also worked closely with the European Commission and other Member States to develop the RSC Decision relating to the 2.6GHz band, which was agreed on 2 April 2008.

Structure of this document

2.11 This Statement is structured as follows.

i) Section 3 sets out the legal framework and our objectives for the award. It explains our decisions on the timing of the award.

ii) Section 4 sets out our decisions on non-technical licence conditions (absence of roll-out obligations, technology neutrality, tradability, duration and conditions of tenure, considerations in relation to the 2012 Olympic Games).

iii) In Section 5, we conclude on the analysis of interference conditions between potential users of the 2.6 GHz band, as well as between users of the 2.6 GHz and 2010 MHz bands and other users of adjacent spectrum in the UK and users of the same spectrum internationally. This analysis underpins our decisions in respect of technical conditions for use of the two bands, as well as important aspects of the packaging of spectrum for the auction design.

iv) Section 6 summarises the technical conditions which will be included in licences for use of the 2.6 GHz and 2010 MHz bands.

v) Section 7 discusses the final auction design and rules.

vi) Section 8 concludes on potential conditions on individual bidders in the award (restrictions on BT, spectrum cap, consortia in the award and scope for “opting out” of an applicant group).

vii) Section 9 sets out the next steps for this award.

viii) Annex 1 contains a detailed summary of responses to our three consultations.

ix) Annex 2 sets out the impact assessment for our decisions.

x) Annex 3 provides an update on the general market interest in use of the 2.6 GHz band and the provision of mobile broadband services.

xi) Annex 4 includes an indicative quantification of competition and innovation benefits which we expect to be realised as a result of the award.

xii) Annex 5 is a confidential annex on an issue raised in a confidential response to our consultations. We have edited the text of this annex out of the published version of this Statement.

xiii) Annex 6 includes our assessment of interference risks in respect of PMSE services.

xiv) Annex 7 summarises the analysis relevant to international coordination with France and Ireland.

xv) Annex 8 contains our assessment of interference risks in respect of Globalstar's satellite service.

Section 3

Legal framework, method and timing of award

Introduction and decisions

3.1 This Section considers whether these spectrum bands should be awarded, and if so, the timing and method of the award.

3.2 In summary, the decisions we have taken on these matters are that we should:

- award the spectrum bands, in light of our usual practice to make spectrum that is not being used available to the market, and our obligations under the recent RSC Decision relating to the 2.6 GHz band;
- proceed with the award of the 2.6 GHz band as soon as possible rather than take a conscious decision to delay the award until some later date (e.g. beyond 2008);
- award the 2010 MHz band as part of the same award process as the 2.6 GHz band; and
- award the 2.6 GHz and 2010 MHz bands via auction.

3.3 In setting out our reasoning, we begin this Section with an overview of the legal framework for evaluating our approach to the award. Against this background we set out (in paragraphs 3.22 to 3.65) a summary of the rationale that has led us to take the above decisions, drawing on the more detailed analysis and consideration of responses to our consultations which are presented in paragraphs 3.116 to 3.197.

Legal Framework for the award and summary of conclusions that flow from this

3.4 The legal framework for the award derives from the European communications directives, and specifically from the Framework Directive[8] and the Authorisation Directive.[9] The relevant provisions of these directives (see further below at paragraphs 3.5 to 3.10) are transposed into UK law by the Communications Act 2003 (the 2003 Act) and the Wireless Telegraphy Act 2006 (the 2006 Act).

European Communications Framework

3.5 Article 8 of the Framework Directive sets out the objectives which national regulatory authorities must take all reasonable steps to achieve. These include:

- the promotion of competition in the provision of electronic communications networks and services by, amongst other things encouraging efficient investment in infrastructure and promoting innovation, and encouraging efficient use of radio frequencies; and

[8] Directive 2002/21/EC of 7 March 2002
[9] Directive 2002/20/EC of 7 March 2002

- contributing to the development of the internal market by, amongst other things, removing obstacles to the provision of electronic communications networks and services at a European level, encouraging the interoperability of pan-European services, and ensuring that, in similar circumstances, there is no discrimination in the treatment of undertakings providing electronic communications networks and services.

3.6 Article 8 also requires Member States to ensure that in carrying out their regulatory tasks, national regulatory authorities take the utmost account of the desirability of making regulations technologically neutral.

3.7 Article 9 of the Framework Directive requires Member States to ensure the effective management of radio frequencies for electronic communications services in accordance with Article 8, and to ensure that the allocation and assignment of radio frequencies is based on objective, transparent, non-discriminatory and proportionate criteria. Article 9 also requires Member States to promote the harmonisation of use of radio frequencies across the Community, consistent with the need to ensure effective and efficient use of frequencies.

3.8 Article 5 of the Authorisation Directive provides that where it is necessary to grant individual rights of use of radio frequencies, Member States must grant such rights through open, transparent and non-discriminatory procedures.

3.9 Article 7 of the Authorisation Directive provides that where Member States decide to limit the number of rights of use to be granted for radio frequencies, they must give due weight to the need to maximise benefits for users and to facilitate the development of competition.

3.10 The legal duties imposed on the UK by the Framework and Authorisation Directives are transposed into UK law and given effect to by the 2003 Act and the 2006 Act.

The duties imposed by the 2003 Act

3.11 Section 3 of the 2003 Act sets out Ofcom general duties and provides that its principal duties are:

- to further the interests of citizens in relation to communications matters, and
- to further the interests of consumers in relevant markets, where appropriate by promoting competition.

3.12 In securing the above duties, section 3(2) provides that Ofcom is required, amongst other things, to secure the optimal use for wireless telegraphy of the electro-magnetic spectrum and the availability throughout the UK of a wide range of electronic communication services.

3.13 Section 3(3) of the 2003 Act provides that in performing its principal duties, Ofcom must in all cases have regard to the principles of transparency, accountability, proportionality and consistency, as well as ensuring that its actions are targeted only at cases in which action is needed.

3.14 Section 3(4) of the 2003 Act requires Ofcom in performing its principal duties, to have regard to a number of factors as appropriate, including the desirability of promoting competition, encouraging investment and innovation in relevant markets, and

encouraging the availability and use of high speed data transfer services throughout the UK.

3.15 Section 4 of the 2003 Act requires Ofcom to act in accordance with the six Community requirements, which give effect to the requirements of Article 8 of the Framework Directive.

The duties imposed by the 2006 Act

3.16 Section 3 of the 2006 Act imposes a number of further duties relating to spectrum management. Amongst other things, in carrying out its spectrum functions Ofcom is required to have regard to the extent to which spectrum is available for use, and the demand, both current and future, for the use of spectrum.

3.17 Section 3 of the 2006 Act also requires Ofcom to have regard to the desirability of promoting the development of innovative services and competition in the provision of electronic communications services.

Our obligations under the recent RSC Decision relating to the 2.6GHz band

3.18 On 2 April 2008, the Radio Spectrum Committee of the European Commission agreed the text of a decision (the "RSC Decision") relating to the 2.6GHz band. The RSC Decision will be binding on Member States when it comes into force, which is expected to be in early June 2008. It requires Member States to designate the 2.6 GHz band within 6 months of the decision's entry into force and subsequently make it available on a non-exclusive basis for terrestrial systems capable of providing electronic communications services, subject to a number of technical parameters relating to harmful interference.

3.19 Recital 9 to the RSC Decision clarifies that the results of the technical work undertaken by CEPT and which form the basis of the technical parameters of the RSC Decision should be "made applicable in the Community and implemented by Member States without delay".

Application of our duties to this award and objectives

3.20 In making decisions in relation to this award, we have given careful consideration to the duties imposed on us by the European legislative framework and the corresponding UK legislation as set out above.

3.21 Taking into account the relevant facts and circumstances, we consider that our principal duty to further the interests of consumers, where appropriate by promoting competition, is of particular importance to this award. In fulfilling this duty, we consider that our duties to secure optimal use of spectrum, promote innovation, and secure the availability of a wide range of electronic communications services are also of particular significance. These duties therefore determine our objectives for this award.

The spectrum bands which are the subject of the award

3.22 The 2010 MHz band and the 2.6 GHz band which are the subject of this award constitute a significant amount of spectrum, totalling 205 MHz, and as such form a greater bandwidth of spectrum (in the range of frequencies considered suitable for mobile communications) than we or our predecessor as spectrum management authority, the Radiocommunications Agency, have ever awarded in the past. The

190 MHz in the 2.6 GHz band makes up the vast majority of the spectrum available under this award.

3.23 Given its bandwidth and propagation characteristics, the 2.6 GHz band in particular is a highly valuable spectrum band which is suitable for a wide range of uses including current and developing services to provide high speed mobile broadband services.

3.24 The main potential uses for the 2.6 GHz and 2010 MHz bands are:

a) mobile broadband services, optimised for data and for which voice is one potential data application in the form of Voice over IP, using WiMAX technology;

b) advanced mobile telephony and data services, using existing (3G UMTS and its evolutions such as HSPA[10]) or future (LTE[11]) 3rd Generation Partnership Project (3GPP) technologies;

c) potentially other uses such as mobile multimedia based on other technologies

- such as entertainment services using DVB technology, e.g. Sprint Nextel in the US is using this technology to provide services at sporting events; or
- wireless cameras and video links for Programme Making and Special Events.

The significance of the 2.6 GHz band in Europe

3.25 The significance of the 2.6 GHz band in particular as a band which could be used to supply pan-European mobile voice and high speed data services is recognised across Europe. It has been the subject of extensive work in various European technical fora (such as the CEPT project team SE42 with its work on the WAPECS mandate[12]) which have developed technical parameters in relation to both the 2.6 GHz band and the 2010 MHz band.

3.26 As a result of this work, the European Commission has, as set out above, in co-operation with Member States including the UK prepared a decision on the 2.6GHz band, which Member States unanimously agreed at the meeting of the Radio Spectrum Committee of the European Commission (RSC) on 2-3 April 2008. This RSC Decision will be binding on Member States when it comes into force, which is expected to be in early June 2008.

The spectrum is currently significantly under-used

3.27 The 2010 MHz band is currently unused and the 2.6 GHz band is significantly under-used. The 2.6 GHz band is currently licensed to users for programme making and special events (PMSE) who use it on an ad hoc basis for wireless cameras and video links. Such users we notified of the need to vacate the band in 2002 and those remaining have held annual licences revocable on 3 months' notice since 1 January 2007. We will revoke those licences before completing the award. Arrangements for PMSE access to spectrum will be the subject of the consultation on the detailed

[10] High Speed Packet Access, a development of existing 3G/UMTS standards
[11] Long Term Evolution, a term covering the potential next generation of cellular mobile technologies in the 3GPP UMTS family and likely to require spectrum in blocks of 2x10 or 2x20 MHz if used at 2.6 GHz
[12] Wireless Access Policy for Electronic Communications Services, a concept developed by the EU's Radio Spectrum Policy Group. See their opinion of 23 November 2005, available at http://rspg.ec.europa.eu/doc/documents/opinions/rspg05_102_op_wapecs.pdf.

design of the Digital Dividend Review band-manager award in the spring. As a result, the spectrum bands which are the subject of this award and which constitute a significant, valuable and scarce resource are currently available for new uses.

The spectrum should be made available for wider use

3.28 It is our usual practice to make spectrum which is not being used available to the market (see for example paragraph 1.12 of the SFR:IP Interim Statement), in accordance with our statutory duties to secure optimal and efficient use of the spectrum. In this case, all stakeholders have agreed that the bands should be made available for wider use than is currently the case.

3.29 The RSC Decision, which was formally agreed at the RSC meeting on 2-3 April 2008, requires Member States to designate the 2.6 GHz band and subsequently make it available on a non-exclusive basis for terrestrial systems capable of providing electronic communications services.

3.30 We therefore conclude that we should make the spectrum bands available.

Consultation in respect of the award

3.31 We have formally consulted extensively in relation to this award on three occasions over the past two years, in December 2006, August 2007 and December 2007. Moreover, these consultations have been accompanied by a series of seminars and discussions with interested parties. Stakeholders have therefore had considerable opportunity to put forward their views, and we have received many responses to our consultation documents. We have taken these fully into consideration in preparing this Statement. We have also taken into account, where relevant, the responses to the consultation on mobile spectrum liberalisation[13].

3.32 All stakeholders have agreed that the band should be made available for wider use than is currently the case. However, stakeholders have presented diverging views as to the timing and conditions of making such use available.

3.33 A number of respondents have stated that they consider the spectrum should be made available as soon as possible. Typically, they propose to deploy WiMAX or other next generation technologies to supply mobile broadband services. These operators are likely to be new entrants to the provision of mobile services, most of whom do not currently hold licences for the use of other parts of the spectrum that would allow them to supply mobile services and for whom success in this award would represent their first such licences. Moreover, it is likely that the deployment of new technologies will enable the delivery of innovative new services. This group of stakeholders has emphasised to us their view that there is currently a window of opportunity to introduce services based on technologies such as WiMAX, which would give them a chance of establishing themselves before existing mobile broadband technologies are developed to a similar or more advanced standard. They argue that any delay to the award would narrow this window and that a substantial delay may close it altogether.

3.34 Another group, including most of the existing mobile network operators (MNOs) and some equipment vendors, has strongly argued that the award should be delayed until

[13] See the document entitled “Application of spectrum liberalisation and trading to the mobile sector including implementation of the Radio Spectrum Committee Decision on 900 MHz and 1800 MHz” published in September 2007 at http://www.ofcom.org.uk/consult/condocs/liberalisation/.

a number of uncertainties have been resolved or further clarified. Those stakeholders in this group are typically existing competitors in the provision of mobile services who could use the spectrum to deploy further 3G capacity as part of their existing networks, or to deploy next generation technologies such as LTE (Long Term Evolution) to deliver mobile broadband services, once these are developed in the future.

3.35 In light of the stark divergence of stakeholder views on when we should proceed with the award and of the arguments put to us that the costs of proceeding now may be considerable, we have considered carefully the benefits and costs of proceeding now, as well as the benefits and costs of delaying the award.

The benefits of proceeding now outweigh the costs

3.36 For the reasons set out below we consider that the benefits of proceeding now outweigh the costs.

There are likely to be substantial benefits in awarding the spectrum as soon as possible

3.37 There is evidence of significant demand for the 2.6 GHz band and significant interest in gaining access to the 2.6 GHz band now. The evidence of demand is considered in greater detail at paragraphs 3.70 to 3.82 and in Annex 3. Awarding the spectrum as soon as possible is likely to bring a number of benefits. These are considered in detail at paragraphs 3.83 to 3.105. In summary, they are benefits which will:

- promote competition in the market, through likely new entry and the deployment of new technologies to compete with existing technologies, to the overall benefit of consumers;
- secure optimal use of an important spectrum band which is currently underused, given that there is strong demand to use the 2.6 GHz band now;
- promote innovation and widen the range of services available to consumers, since it would allow new mobile broadband services to be offered to the market now, using technologies such as WiMAX.

3.38 We note that that there is a risk that the window of opportunity for new service providers to establish themselves using new technologies may disappear if the spectrum is not awarded as soon as possible. If this occurs, the innovation (and competition) benefits from awarding this spectrum are likely to be substantially lower.

3.39 In light of the significant demand for the spectrum, we consider that the judgement of balancing costs and benefits of alternative uses of the spectrum should be left to the market, as participants in the market are inherently better placed than regulators to assess option values for spectrum use and to make decisions under uncertainty. By holding the award as soon as possible, we are enabling stakeholders to decide whether to participate in the award and what value they place on the spectrum. On the other hand, delaying the award would require us to arbitrate between different groups of stakeholders based on poorer information than that held in the market. Hence, the risks of errors in allocating the spectrum appear to be much greater under a regulatory decision to delay the award than under a market driven approach in which operators themselves decide whether and how to participate in an auction.

The costs of delay are likely to be significant, and outweigh any potential benefits of delay

3.40 The costs of delay relate to forgoing the benefits from awarding the spectrum as soon as possible. These are considered in detail below at paragraphs 3.106 to 3.115.

3.41 These costs (or forgone benefits) are likely to be significant and could be in the order of several hundreds of millions of pounds for each year of delay, although we emphasise that any estimate of this nature should be regarded as an illustration of order of magnitude only. As explained above, if the window of opportunity for new entrants closes because of a delay to the award, the costs of delay would increase substantially.

3.42 The stakeholders in favour of a delay to the award rely predominantly on the existence of uncertainties arising from the ongoing process of mobile spectrum liberalisation, arguing that until Ofcom clarifies how mobile spectrum liberalisation is to be implemented, they are unable accurately to assess their likely demand for, and therefore their valuation of, the 2.6 GHz band. Their responses to our consultations are addressed in detail at paragraphs 3.116 to 3.197.

3.43 The MNOs have taken widely differing positions in their responses to our consultation on mobile spectrum liberalisation regarding potential implementation options. It is therefore difficult to ascertain from those responses a clear proposition for how we could judge when the uncertainty over mobile spectrum liberalisation had, in their view, reduced sufficiently to allow the award to proceed. It is clear, however, that mobile spectrum liberalisation is a complex project and may take a significant period of time to resolve. Moreover, the uncertainties that mobile spectrum liberalisation could create for valuations of 2.6 GHz spectrum could not be fully removed until after any process for reassignment of 2G spectrum (should we ultimately decide that any such reassignment is necessary) had taken place, a process that might not be concluded for several years.

3.44 Moreover, we do not consider that any uncertainties arising from mobile spectrum liberalisation are likely to be dominant, given the range of uncertainties that are relevant to this spectrum award, and given the existence of a range of uncertainties which stakeholders face on an ongoing basis.

Other relevant considerations

Effect of our decision on stakeholders

3.45 Some existing MNOs have argued that a decision to proceed now with the award would discriminate against them because of the uncertainties which they alone face (see further paragraphs 3.176 to 3.181). We acknowledge that different stakeholders are in different positions and that where, as here, one group is arguing in favour of an award now, whilst another is in favour of delay, it is inevitable that both groups will not be affected in the same way by our decision. This would be the case whether that decision was a decision to proceed now or one to delay the award.

3.46 We consider that we should proceed in a manner which best meets our statutory objectives, whilst seeking to minimise as much as possible any differential effect on stakeholders which may result. On the basis of our analysis of the evidence, we consider that a decision to proceed now best meets our statutory objectives, and that sufficient factors exist to conclude that a decision to proceed does not unduly discriminate against those stakeholders who argued in favour of a delay, particularly

as none of them is precluded from participating in the award as a result of our decision.

Alternative proposal to award only part of the spectrum now

3.47 We do not consider that the proposal suggested to us by one stakeholder, to award only part of the 2.6 GHz band now, would be capable of achieving the same aims as holding an award of the whole of the spectrum would (see paragraphs 3.182 to 3.197).

3.48 We consider that our decision to proceed to hold an award for the whole of the 2.6 GHz band and the 2010 MHz band as soon as possible is a proportionate means by which to achieve our aims and to fulfil our statutory duties, including in particular our duty to further the interests of consumers.

Conclusions on timing of award based on our statutory duties

3.49 We have considered the factual background to this award in light of our statutory duties and have had regard to the extent to which the spectrum is available for use, and the demand, both current and future, for its use.

3.50 In accordance with our usual practice, we consider that we should make the spectrum available for wider use than is currently the case. This conclusion is reinforced by the RSC Decision which includes a requirement to make the band available for terrestrial systems capable of providing electronic communications services.

3.51 We face balancing two competing interests in deciding the timing of the award of the 2.6 GHz band. On the one hand, the spectrum is currently underused and there is strong demand to use it now. A number of stakeholders have expressed their interest in using the 2.6 GHz band as soon as possible. Many of those stakeholders are proposing to deploy new technologies such as WiMAX, and are likely to bring new mobile broadband services to the market. Many also do not currently hold licences for comparable spectrum, and this band would be their first such spectrum input. This demand we are seeing to use the band is underpinned by a growing momentum internationally to use the band for similar services using WiMAX (and other) technology. Manufacturers are developing equipment, companies are taking part in spectrum auctions, operators are rolling out networks and developing new services.

3.52 On the other hand, some stakeholders have argued that we should delay the award of the band, in whole or in part, until a number of uncertainties have been reduced. These stakeholders are mainly MNOs, established providers of services which hold licences for substantial spectrum resources, and for which new holdings at 2.6 GHz would be an addition. Current indications are that they may use the spectrum to provide existing services, or that they may deploy new technologies, such as LTE which is expected to be available in a few years, to offer mobile broadband services.

3.53 One of our principal duties under the 2003 Act and the underlying European legislative framework is to further the interests of consumers, where appropriate by promoting competition. The current under-use of the spectrum bands means that the spectrum is not currently being used in a way which promotes competition. However, given the attractive physical characteristics of the spectrum and the fact that it has for some time been identified internationally as suitable for the provision of high speed mobile broadband services, it is likely that making it available now would stimulate competition both in the form of competition between technology standards as well as

in the form of competition from new entry. We believe that competition of this nature would be likely to have significant beneficial effects for consumers.

3.54 We are required to secure optimal use of spectrum in the UK. The 2010 MHz and the 2.6 GHz bands are valuable spectrum bands which are currently either not being used, or are being significantly under-used. Making the bands available for wider use as soon as possible would be highly likely to result in considerably more optimal use of the spectrum than is currently the case.

3.55 We are also under a duty to have regard to the desirability of promoting innovation in relevant markets. The spectrum bands in this case have been identified internationally for use to provide mobile broadband services, which are not yet available. Respondents to our consultations have explained that they are keen to use the spectrum to deploy new technologies, such as WiMAX, which is capable of supporting high speed mobile broadband services and network management in a way which is not currently available. We note that that there is a risk that the window of opportunity for new service providers to establish themselves using new technologies may disappear if the spectrum is not awarded as soon as possible. If this happens, the innovation (and competition) benefits that could be generated through new entry as a result of awarding this spectrum are likely to be substantially reduced.

3.56 The combination of these duties strongly indicates that we should proceed to award the band as soon as possible.

3.57 This conclusion is supported by a number of further factors:

- first, the RSC Decision relating to the 2.6 GHz band which was agreed on 2 April 2008 requires the UK to make the band available. We consider that the harmonising nature and intention of the RSC Decision, as well as the text itself, suggest that this should be done without delay;

- second, regardless of the RSC Decision, the level of demand which exists to use the spectrum now supports the case that if the spectrum is awarded now, it will be used more effectively and efficiently than is the case at present and is likely to promote competition and innovation as described above;

- third, given the most likely use of the spectrum, awarding it now is likely to be in accordance with our duty to encourage the availability and use of high speed data transfer services;

- fourth, there appears to be a window of opportunity now for new technologies such as WiMAX to seek to establish themselves before existing mobile broadband services are developed to a comparable extent, and delaying the award would risk narrowing this window to a point where new entry may be considerably less likely than it is now; and

- fifth, as set out in more detail in Section 4 of this Statement, we will make the spectrum fully tradable. This means that the outcome of the initial award process now will not necessarily determine the future of the use of the spectrum for the duration of the licences awarded. If some stakeholders value the spectrum more than others in the future, they will be able to negotiate with licence holders then with a view to acquiring spectrum when they consider they need it.

3.58 We have conducted a thorough analysis of the benefits and costs of our proposal to proceed to award the spectrum now, and have concluded that the benefits of proceeding now considerably outweigh the potential costs.

3.59 We have considered the likely effect on stakeholders of a decision to proceed, and have concluded that it does not discriminate unduly against any one stakeholder or group of stakeholders.

3.60 Finally, we have considered whether an award of part of the band now (as proposed by one respondent) would be capable of achieving the same duties and objectives as an award of the whole of the band would. We have concluded that an award of part of the band now would not be capable of similarly fulfilling our statutory duties and achieving the same aims as an award now of the whole band would be able to do. We consider that our approach is a proportionate means of fulfilling our duties and objectives.

3.61 We therefore conclude that on the basis of our statutory duties as applied to the facts in this case, we should proceed to award the spectrum as soon as possible.

Method for awarding the 2.6 GHz and 2010 MHz bands

3.62 It is our view, as set out in the December 2006 Consultation, that an auction would be the most appropriate method for authorising use of the spectrum bands. This view is also consistent with the view we put forward in the Spectrum Framework Review: Implementation Plan, that an auction is likely to be the best method of awarding the spectrum where demand exceeds supply.

3.63 We consider 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 spectrum 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.

3.64 We received an overwhelmingly positive response to the December 2006 Consultation on the issue of how the 2.6 GHz and 2010 MHz bands should be awarded. All of the respondents (with the exception of 1 out of 35 responses) agreed that the bands should be awarded through an auction process.

3.65 We have therefore decided that 2.6 GHz and 2010 MHz bands should be awarded via an auction mechanism.

Underlying reasoning to support our decision to proceed now, and consideration of responses to our consultations

3.66 In the preceding part of this section, we set out our conclusions and an overview of our reasoning to support our decision to proceed to award the spectrum as soon as possible. The following parts of this section set out the analysis we have undertaken in order to reach our conclusions, including our consideration of the responses to consultations, particularly those arguing in favour of delaying part or all of the award.

3.67 These parts are set out as follows:

- First, we consider the evidence of demand for the 2.6 GHz and 2010 MHz bands and the interest in bringing them into use as soon as possible (paragraphs 3.69 to 3.82), focusing on:
  - the evidence of demand to use the spectrum in the UK; and
  - in addition, considering the evidence of demand for the 2.6 GHz band in other countries, which demonstrates the momentum building around new technologies which may be deployed in the band.
- Second, we consider the benefits of bringing the 2.6 GHz band into use as soon as possible (paragraphs 3.83 to 3.105), and in particular:
  - our view that competition benefits are likely to arise from bringing the 2.6 GHz band into use; and
  - our view that innovation benefits are likely to arise from bringing the 2.6 GHz band into use.
- Third, we consider the costs of delaying the award (i.e. the forgone benefits of holding an award as soon as possible) (paragraphs 3.106 to 3.112).
- Fourth, we consider the benefits of delaying the award (paragraphs 3.113 to 3.115).
- In the remaining sub-sections, we consider responses to the December 2006 Consultation and the Discussion Document which relate to the timing of the award (paragraphs 3.116 to 3.197), where we consider:
  - responses arguing for the award of the band as soon as possible (paragraphs 3.118 to 3.119);
  - responses arguing for a delay to the award (paragraphs 3.120 to 3.127);
  - whether there is a risk that uncertainty will lead to an inefficient award if the 2.6 GHz band is awarded as soon as possible focussing specifically on our consideration of the arguments put forward for delaying the award (paragraphs 3.128 to 3.130);
  - whether uncertainty over mobile spectrum liberalisation is likely to have a material effect on the 2.6 GHz award (paragraphs 3.132 to 3.163), specifically-
    - the nature of uncertainty over mobile spectrum liberalisation;

- the significance of uncertainties over mobile spectrum liberalisation for valuing 2.6 GHz;
- whether uncertainty over 2G liberalisation would have a material effect on the award of 2.6 GHz;

- whether trading will enable future changes in the allocation of 2.6 GHz spectrum (paragraphs 3.164 to 3.171);
- conclusions on the impact of mobile spectrum liberalisation uncertainty on the award of the 2.6 GHz band (paragraphs 3.172 to 3.182);
- one respondent's alternative proposal to award only part of the 2.6 GHz band now (paragraphs 3.182 to 3.197), specifically-
  - our concerns with the proposal relating to market entry, competition and innovation;
  - our assessment of the respondent's view that the proposal would reduce uncertainty and increase the efficiency of the award.

3.68 The following sections focus on the 2.6 GHz band as this band is expected to represent the majority of the value of the spectrum available in this award and so drives the decision on timing of the award.

The interest in bringing the bands into use as soon as possible

3.69 There is evidence of significant demand for the 2.6 GHz band in the UK and internationally.

Evidence of demand to use the spectrum in the UK

3.70 The information available to us indicates that there is considerable interest in gaining access to the 2.6 GHz band in the UK. A number of parties have expressed interest in using the band in the imminent future, in particular for the delivery of services using mobile WiMAX. These indications of interest have been given to us during our consultations and in discussions with a number of parties over the past year, our understanding of which has been updated in recent exchanges in January and February 2008. Moreover, those expressing interest in the band, as well as several manufacturers, have supported the proposal to award the band as soon as possible.

3.71 Interest in gaining imminent access to the 2.6 GHz band has been expressed both by large established companies already providing telecommunications services as well as by smaller companies seeking to develop new services using the 2.6 GHz band. In general, these parties want to acquire TDD spectrum for WiMAX based services and, if one or more of these parties were successful in the award, this would lead to the entry of new competitors providing services such as mobile broadband services.

3.72 In addition, feedback indicates that at least some of the existing MNOs (and possibly others) would also be likely to participate in an award if it were held as soon as possible, even though they might prefer the award to be delayed until they had more immediate need to use the spectrum. This feedback suggests that their participation would be with the intention of acquiring spectrum for use in future years, for example when LTE based services become sufficiently technically developed and / or when extra capacity is needed on 3G networks.

3.73 We are aware that the only absolute test of whether there is demand for use by operators is actually to hold the award. We also note that, in previous auctions, parties that have not made themselves visible during the consultation process have also come forward to participate in the auction. However, on the basis of our conversations we are persuaded that real interest exists and that if the award is held in 2008 then it is very likely that there will be parties who will participate in the award who, if successful, intend to bring the spectrum into use without delay. More evidence in relation to the demand for the use of the 2.6 GHz band in the UK and for mobile broadband services is set out at Annex 3.

Evidence of demand for the 2.6 GHz band in other countries

3.74 There is also strong interest in using the 2.6 GHz band internationally, as demonstrated by broader anecdotal evidence. Annex 3 provides details on:

- recent developments and investments relating to the main candidate technologies for the 2.6 GHz band;
- recent and upcoming awards of the 2.6 GHz band worldwide, and current use of the 2.6 GHz band where it has already been assigned; and
- general trends in demand for mobile broadband services.

3.75 Evidence of international demand for the 2.6 GHz band is significant for this award because it demonstrates the momentum building around the new technologies which are most likely to be used by any new entrants in this band, as well as the pace of development in technologies that could be used by existing providers of mobile broadband services in this band.

3.76 There are indications of significant investment and development of innovative services based on WiMAX technologies where operators have gained access to suitable spectrum. For example, a number of manufacturers have developed and are developing network and user equipment for mobile WiMAX (for example Samsung and Intel), WiMAX-based services are available in South Korea and Sprint-Nextel plans to launch WiMAX-based services in selected geographical markets in the US later in 2008. In Japan, a consortium led by KDDI and Intel won a licence to use the 2.6 GHz band at the end of 2007 and has announced substantial roll-out and investment plans (with a reported investment of US$ 1.3 billion).

3.77 There are also signs of accelerated developments in competing technologies, notably LTE, in response to the development of WiMAX. A number of major operators, including Verizon Wireless, AT&T, China Mobile and Vodafone, have recently announced their backing for LTE. The Mobile World Congress in Barcelona in February 2008 saw a number of equipment manufacturers demonstrate LTE technology. A number of trials have been taking place under the LTE/SAE (Systems Architecture Evolution) Trial Initiative and initial results were announced in November 2007.

3.78 There is a competitive process in train between supporters of the 3GPP[14] and the IEEE standards setting bodies in relation to the standard for advanced mobile broadband services with 3GPP developing the LTE standard and IEEE developing the mobile WiMAX standard 802.16e.These standards embody (in the case of both

[14] 3GPP is the industry body responsible for developing detailed standards for mobile technology in the 3G (UMTS/HSPA) and LTE family.

LTE and WiMAX) a range of new techniques such as OFDM[15], MIMO[16], beam forming and an all IP architecture, that is likely to offer significant cost and bandwidth advantages over current 3G standards (although current 3G standards are themselves developing via HSPA[17] for example).

3.79 This competition in standards is likely to drive competition in innovation in services delivered to consumers. The 2.6 GHz band is central to this competitive process since it provides the spectrum location where both WiMAX and LTE can be deployed in the near term. In this context:

- the WiMAX standard is ahead of the LTE standard in terms of readiness to deploy and, in particular, appears to be ready for deployment in 2008 (indeed, Sprint is currently rolling out a WiMAX network in the US); and
- there are however also signs that LTE could be available towards the end of 2009 or in early 2010.

3.80 A number of spectrum awards at 2.6 GHz have taken place in the last year, e.g. in Japan, Norway, New Zealand and Taiwan, and these have demonstrated substantial demand for this spectrum. Further awards are planned in 2008 in Austria, Germany, the Netherlands, Sweden and Thailand. Moreover, new service providers intending to deploy services using WiMAX and technologies have won spectrum in some of these awards such as Craig Wireless (and other smaller providers) following successful bids in Norway and New Zealand.

3.81 Market forecasts and other data summarised in Annex 3 indicate a very significant potential demand growth for mobile broadband services in both the near term and longer term, with double digit compound growth rates over a sustained period of time. This is of particular relevance since the 2.6 GHz band is most likely to be used to deliver a variety of mobile broadband services.

3.82 This shows that the interest in using the 2.6 GHz band in the UK is entirely consistent with a wide and growing interest across the world. The plans developed by manufacturers of equipment and by new operators at 2.6 GHz suggest that innovative mobile devices and services are likely to be deployed in this spectrum band.

Benefits of bringing the 2.6 GHz band into use as soon as possible

3.83 We now consider the potential benefits of making the spectrum bands available as soon as possible, focusing particularly on those benefits which relate to our principal objective for this award of furthering the interests of consumers, where appropriate by promoting competition.

3.84 Most of the evidence of demand for imminent use of the spectrum appears to be from potential new entrants to the provision of mobile services using new technologies such as WiMAX to offer higher speed mobile broadband services than are currently available to consumers. Although we focus on the benefits that could be provided under this scenario, we do not rule out that incumbent MNOs might also want to use the spectrum to provide services using WiMAX. It is also possible that incumbents might want to deploy LTE networks in the relatively near future (which would offer a

[15] Orthogonal Frequency Division Multiplexing
[16] Multiple Input Multiple Output, a type of antenna
[17] High Speed Packet Access, a development of existing 3G/UMTS standards.

rational upgrade path from their current cellular networks), if and when LTE becomes available.

3.85 First, we consider that there are likely to be considerable benefits to consumers from bringing the spectrum into use as soon as possible, which fall into the following categories:

a) **competition benefits** - entry by players using WiMAX or other technologies (who may offer both services which compete with incumbents and new services) is likely to lead to greater competition which in turn would lead to increases in total welfare (i.e. net consumer and producer benefits) through reductions in prices and increased output;

b) **innovation benefits** - consumers will benefit directly from services which may be offered using 2.6 GHz spectrum. In particular we believe it is likely that these will include a range of new services that are not available now[18]. Further, new services such as high speed mobile broadband may trigger a competitive response from incumbents and so lead to further innovation resulting from competition between technology platforms.

3.86 Secondly, we consider that awarding the spectrum as soon as possible would lead to substantial efficiency benefits in that the spectrum is currently both under-used and available for use, and there is demand to use the spectrum.

3.87 Determining the optimal allocation of the 2.6 GHz band is complicated by the fact that the main alternative uses of the band appear to differ in terms of when spectrum might be brought into productive use and because they are subject to continuing market and technology uncertainty. However, we consider that the market is well placed to make this decision, and take account of uncertainties that may affect valuations of the spectrum, and better placed than the regulator since the market is likely to have better information on the value of the spectrum to the various players interested in using it.

3.88 We have also sought to ensure that our auction design for this award reduces or eliminates information asymmetries between players relating to uncertainties that are common to all players. Furthermore, we consider that broader social value (in excess of private value) associated with the potential uses of the spectrum is likely either to be relatively low or similar across different uses. Therefore the private values of bidders in the auction are likely to be a good proxy for the total public value of the spectrum.

3.89 In the next two sections we discuss in more detail the nature and potential scale of competition and innovation benefits that may arise if we award the spectrum as soon as possible. We then discuss the potential impact on these benefits of delaying the award. In discussing the scale of potential benefits, we emphasise that any quantification is, by its nature, highly uncertain. The purpose of the analysis is solely to give an indication of the broad order of magnitude of potential benefits and our conclusions do not depend on the specific numbers.

[18] The nature of new services is not something that we can readily anticipate. However, examples suggested to us include the development of business models in which chips are embedded in a much wider range of devices than is currently the case, including gaming consoles and video cameras etc., that then transmit data over mobile networks.

Competition benefits from bringing the 2.6 GHz band into use

3.90 If new service providers rolling out networks over 2.6 GHz spectrum start to provide mobile broadband services, we consider that it is likely that competition for the provision of mobile broadband services will increase and that this will generate net welfare benefits; for example consumers may enjoy lower prices and/or output may increase.

3.91 We note that, respondents to the mobile spectrum liberalisation consultation queried whether a change in the structure of mobile services provision would necessarily lead to an increase in competition and suggested that the mobile retail market was competitive. However, we consider that there is a solid theoretical and regulatory foundation for considering that entry will increase competition[19]. The majority of oligopoly models commonly used in analysing competition and merger issues in oligopoly also predict this result[20].

3.92 The only oligopoly model which does not produce this result (the Bertrand model according to which firms compete on the basis of price, with the assumption of homogenous products) does not appear to fit the facts of the industry. Services do not appear to be homogenous since there is significant differentiation in mobile services, e.g. different tariff packages, service and handset functionalities and coverage (for mobile broadband services). Moreover, the model assumes no fixed and sunk costs and no capacity constraints; these assumptions do not apply here in practice. Furthermore, empirical evidence regarding mobile services also finds a positive link between the number of players and competition in mobile markets[21].

3.93 In our Statement on Mobile Call Termination[22], in March 2007, we put forward our view that although no single or joint dominance was found when mobile access and origination were last reviewed by Oftel in 2003[23] (and competition is likely to have increased since then), there still remains scope for an increase in competitiveness of the market. In other words, the concept of dominance is a threshold whereas the competitiveness of a market is a continuum, and it is possible for the degree of competitiveness to increase even in the absence of dominance. We therefore consider that it is likely that competition would increase as a result of entry into the mobile market.

3.94 We recognise that the 2.6 GHz band is not the only spectrum which may be available now or in the near future that would allow entry into the provision of mobile services. For example, restrictions on providing mobile services over spectrum at 3.5 GHz have recently been removed, and tradable 2G and 3G spectrum[24] may provide another source of spectrum for an entrant. However, the significance of the 2.6 GHz

[19] For example the Competition Commission guidelines on merger references
[20] For example: the Cournot model in which firms compete on the basis of quantity of goods offered; more sophisticated variants such as the two-stage model described by Kreps and Scheinkman, in which firms first commit to the capacity which they aim to provide over their networks and then set prices (D. Kreps, J. Scheinkman: Quantity Pre-Commitment and Bertrand Competition Yield Cournot Outcomes, Bell Journal of Economics, 1983); the Bertrand model with product differentiation (in which firms compete on price), and which is extensively used in merger simulation for anti-trust cases.
[21] H. Koski and T. Kretschmer, "Entry, standards and competition: firm strategies and the diffusion of mobile telephony" Review of Industrial organisation 2004
[22] See in particular paragraphs 7.35-7.37 in the statement available at http://www.ofcom.org.uk/consult/condocs/mobile_call_term/statement/statement.pdf.
[23] http://www.ofcom.org.uk/static/archive/oftel/publications/eu_directives/2003/mobileaco0803.pdf
[24] In the mobile spectrum liberalisation consultation of September 2007, we have proposed making 2G and 3G spectrum tradable.

band in this context is that it currently appears to be central to prospects for deploying advanced mobile broadband technologies:

a) it provides sufficient spectrum to cater for the larger bandwidths likely to be supported by LTE (e.g. 10 and 20 MHz) and to support the use of WiMAX in 10 MHz and 20 MHz channels; these larger channel sizes are key to achieving some of the performance gains - and channels of more than 5 MHz width are likely to be harder to find at the lower, heavily congested frequencies, and they are not available in the near term at other mobile / IMT frequencies;

b) it is the leading band for which WiMAX-based services have been developed for deployment on a global basis so as to support roaming and economies of scale in equipment manufacture. This is because 2.6 GHz is the only band below 3 GHz which is available internationally in the near term[25], although WiMAX profiles may be developed for other frequency bands that may become available for mobile services in future. Further details on the interest in the 2.6 GHz band globally are available in Annex 3.

c) entry by providers using 3.5 GHz may deliver competition benefits. However, we consider that there is unlikely to be a large overlap between benefits arising from use of 3.5 GHz for mobile services and those arising if the 2.6 GHz band is made available as soon as possible. Firstly, mobile broadband equipment at 3.5 GHz is unlikely to be available on the same timescale, or in the same volumes which will drive economies of scale in equipment manufacture, as 2.6 GHz. Secondly, 2.6 GHz has better propagation characteristics than 3.5 GHz which reduces the number of sites required to offer coverage, particularly outside dense urban areas.

3.95 We also note that WiMAX in its current form has been developed for use in unpaired spectrum[26] whereas the main 3G technologies require paired spectrum. Thus the competitive opportunity for WiMAX depends on the availability of unpaired spectrum in the 2.6 GHz band: this underlines the importance that we attach to allowing flexibility between paired and unpaired spectrum as discussed in Section 4 where we set out our decision to make the award of the spectrum technology neutral.

3.96 It is not certain that the benefits of competition referred to above will come about. This will depend on whether the award leads to new entry and on how successful the new entrants are which, in turn, could depend on how WiMAX technology performs in practice. We are aware that there is a diverse range of opinion on the chances of WiMAX making a significant market impact, some of which is sceptical. However, we consider that:

a) the market is better placed to make judgements about the relative prospects of different companies and technologies than the regulator; and

b) the evidence suggests that significant benefits are likely to accrue to consumers from greater competition as a result of awarding the spectrum now.

[25] DDR spectrum is likely to be available in a number of countries internationally (though possibly not throughout the EU), but will not be available for use on a nationwide basis in the UK until late 2012.
[26] A half FDD profile is expected to be developed for WiMAX in due course which will allow WiMAX to be deployed in paired spectrum. However, we understand from the WiMAX Forum that this is unlikely to be ready for several years. The half FDD version also has a disadvantage as compared with the unpaired, TDD version in that it will not have the flexibility to reallocate resources to reflect asymmetric uplink and downlink volumes.

3.97 Awarding the spectrum now also provides an opportunity to remove a significant barrier to entry and allows the market to determine access to spectrum that allows the provision of mobile broadband services. We note that consumers might derive significant indirect benefit through the competitive response of existing operators even if new WiMAX operators have only modest success on their own.

3.98 We have produced an indication of the potential competition benefits from new entry to the market using a Cournot model. In response to the mobile spectrum liberalisation consultation, Vodafone questioned the use of the Cournot model to estimate welfare benefits associated with changes in market structure. We disagree that the Cournot model is unsuitable. Whilst we note its limitations, it captures the fundamental impacts of entry on competition and we consider that it is appropriate for the purpose for which it is being used in that we are only seeking to provide an indication of the potential scale of competition benefits of awarding the spectrum as soon as possible. The Cournot model also has the benefit of being analytically tractable and we do not consider that the additional investigation and analysis required to use one of the more complex oligopoly models (which might be relevant to the provision of mobile services) would necessarily produce a significantly different or more insightful result, given that the purpose of this analysis is only to place a broad order of magnitude on the scale of potential benefits.

3.99 Our model (as described more fully in Annex 4) indicates the welfare benefit from greater competition in the provision of mobile services (assuming new entrants are nation-wide competitors) – the sum of changes in producer and consumer surplus – if the spectrum is awarded as soon as possible, could range from a total welfare gain[27] of £800 million in the case of one additional player (i.e. going from five to six players) to £1.7 billion in the case of three[28] (going from five to eight players). This is the net welfare effect of increases to consumers and losses to incumbents from reductions in prices. For comparison, in the mobile spectrum liberalisation consultation we looked at the impact of a reduction in the number of competitors and our model estimates that a reduction from five to four would lead to a fall in total welfare of around £1.1 billion.

Innovation benefits from bringing the 2.6 GHz band into use

3.100 We consider that innovation benefits are likely to arise in two separate ways as a result of holding an award as soon as possible. First, the spectrum could allow new services to be offered that are not currently being provided. For example, the use of WiMAX technology could allow the provision of much higher speed mobile broadband services than are currently possible.

3.101 Secondly, greater competition (particularly if alternative technology platforms are deployed) may lead to increased innovation as suggested by a substantial body of opinion which is supported by empirical evidence[29]. For example, innovation may be more intense as a result of the threat of competition, or as a response to it. Recent and prospective developments in mobile broadband offer strong support for this view as outlined in paragraph 3.77.

[27] If greater weight were placed on consumer surplus than producer surplus, in view of Ofcom's duties to promote the interests of consumers and citizens, then the gains would be even larger.
[28] 20 year NPV, 2007/8 prices, assuming entry in 2008/9, elasticity of demand of –1 and a real social discount rate of 3.5%
[29] See for example "Competition and innovation: an inverted U relationship" P Aghion, N Bloom, R Blundell, R Griffith and P Howitt, Quarterly Journal of Economics May 2005.

3.102 Furthermore, it appears likely that the threat of WiMAX will encourage 3GPP to develop its LTE standard faster than would otherwise be the case. Indeed, a number of commentators and industry participants have noted that developments in WiMAX have already prompted the recent acceleration of efforts to develop the LTE standard. This threat is likely to be diminished if we delay the award and so reduce the timing window for WiMAX to become established.

3.103 In addition, in the UK incumbent MNOs are likely to respond to new entrant competition in existing mobile broadband markets and may potentially advance their own plans for next generation deployment which they could do using either LTE when it is available (which would present a natural evolution path from 3G) or, possibly, using WiMAX themselves as a complement to their existing 3G networks[30].

3.104 We have produced a high level quantification of the potential innovation benefits of awarding the spectrum as soon as possible. This estimate is only indicative because innovation is by its nature difficult to predict and our model only captures some of the potential innovation benefits. We estimated the potential increase in welfare if awarding the 2.6 GHz band led to an acceleration in innovation by one year. We consider that our assumption of a one-year acceleration in innovation is conservative, though it is difficult to put a precise measure on size of the acceleration[31].

3.105 On this basis, our model indicates the increase in total welfare from greater innovation as ranging from £200 million to £1.4 billion[32]. We modelled the flow of economic benefits over twenty years from 2007/08, both with and without a one-year acceleration[33] in the introduction of new innovations. This wide range is a product of the uncertain nature of the processes we are trying to capture. It depends chiefly on the model's assumptions as to the amount by which innovation increases the economic value generated by mobile services (modelled as a simple uplift on 3G revenues) and how long it takes before the market "catches up" to its original innovation path.

Costs of delaying the award

3.106 In the preceding sub-section we have considered the benefits that could arise from bringing the bands into use in the immediate future. We now consider the extent to which these benefits might be reduced if the award were delayed for a period of time. As above, we derive indicative estimates of the order of magnitude of these costs, or forgone benefits. Again, we emphasise that the estimates are relevant only in so far as they indicate that the costs of delay could be significant.

3.107 If the award of the 2.6 GHz band is delayed, the following types of welfare benefits will be forgone:

[30] Vodafone has been reported as indicating it may choose WiMAX instead of LTE as its next generation mobile technology. See for example AFX's news release of 15 February 2007, 'Vodafone CEO says Ericsson's LTE standard development must be speeded up', available at http://www.forbes.com/technology/feeds/afx/2007/02/15/afx3429008.html.

[31] We have analysed how differences in market structure (e.g. in the UK and Germany as opposed to France) affected the launch of 3G services and this supports our contention that greater competition could accelerate innovation.

[32] 20 year NPV, 2007/8 prices, assuming entry in 2008/9, further advanced services launched in 2014/15 and a real social discount rate of 3.5%

[33] We consider the choice of a one year difference conservative. It is based on an observed correlation in Europe between earlier 3G network roll-out and more 3G players

- benefits to consumers and producers arising from the use of the spectrum will be forgone for the duration of the period of the delay;

- use of the spectrum which would have been economically efficient may not develop at all as a result of the delay.

3.108 For every year of delay, the competition and innovation benefits which would have been gained in that year will be lost. We have used our competition analysis described above, and in more detail in Annex 4, to estimate of the costs of delay in terms of a reduction in competition benefits. Our modelling implies that for each year of delay to the award, competition benefits alone might fall by between £70 million to £150 million (depending on the number of competitors that might enter the market). Those arguing for delay have not indicated how long they believe such a delay might need to be. But, if the 2.6 GHz award were to be delayed until any reassignment of 2G spectrum holdings had taken place (as some of the arguments would seem to imply), then the resulting delay could be for several years.

3.109 It is difficult to produce a meaningful estimate for the impact of a delay on innovation benefits. Given that we have represented innovation benefits as bringing forward by one year the launch of services delivered over the next generation of technology standards, the impact of a delay on innovation benefits is particularly uncertain. It is possible that the launch of services delivered over the next generation of technology standards might still be accelerated, but by less than one year. Alternatively, it is possible that they might not be brought forward at all. However, we stress that the impact on innovation benefits could add significantly to the costs of a delay. Further, there are a number of other innovation benefits for which we were not able to produce sensible estimates at all. For example, awarding the spectrum could (as discussed) increase the pace of innovation and development for mobile broadband technologies other than WiMAX, such as LTE.

3.110 Moreover, the impact of a delay could be substantially larger than the effect of deferring benefits on its own. Potential new entrants have suggested that there is a limited window of opportunity for new entrants to launch mobile broadband services. This is because existing MNOs would enjoy substantial incumbency advantages in launching mobile broadband services, such as existing brand awareness, customer base and network infrastructure. If WiMAX providers cannot access the spectrum soon, they could find it very much more challenging to build up a significant presence or sufficient awareness of their product to compete effectively when the incumbents roll out future competing technologies such as LTE. There may be a significant risk, therefore, that delay would close the window of opportunity for potential new entrants, in which case the costs of a delay could be substantially greater than the order of magnitude figures we give above.

3.111 It is important to note that the costs of delaying the award would be borne in the first instance by consumers, who would be denied the opportunity to enjoy services delivered over new technologies for the duration of the postponement of the award. New entrants would also bear costs of delay, as they would be denied the opportunity to develop new technologies and services. The costs would not be borne by the existing MNOs who have argued in favour of a delay. In fact, it is likely that a delay would have advantages for MNOs in terms of delaying or denying this source of potential new competition.

3.112 At a general level, we note that research into the impact of not awarding spectrum finds that substantial welfare benefits can be forgone[34]. Furthermore, delaying the award of the 2.6 GHz band also appears likely to result in the UK falling behind other countries in terms of innovation in wireless service offerings, given that a number of other countries worldwide have recently authorised or are now authorising the use of this band for new mobile services for example: USA; Taiwan; Japan; New Zealand; Norway; Sweden; Austria and probably India (see Annex 3 for further details).

Benefits of delaying the award

3.113 The case that delaying the award for perhaps a few years might increase consumer benefit, compared to an award that is held as soon as possible, is based on the argument that there is a class of potential users (primarily the existing MNOs) who:

- do not have an immediate need for the spectrum but may derive value from making productive use of it in a few years; so if the award were held as soon as possible they could be forced to participate in the award to secure spectrum for future use ahead of need; and

- are faced with uncertainties now about how much spectrum they may require, and about the time at which they might require it; their assessment of future requirements and, hence, their valuations of 2.6 GHz spectrum, will be less well informed now than if they needed to make these assessments in a few years' time.

3.114 To the extent that these stakeholders base their valuations of 2.6 GHz spectrum on projections and valuations that turn out to be materially less accurate than would be the case for an auction held at a later date, then this could lead to an auction outcome which is revealed, in future years, as being less efficient (in that those parties that win the 2.6 GHz spectrum now and so hold it in a few years' time when a delayed auction might have been held, turn out not to be those that could create the greatest value through its use at that time).

3.115 This rationale underlies the arguments put forward by those respondents requesting a delay. Hence, we consider the strength of this argument in detail below where we discuss our evaluation of responses to our consultations on the question of timing (from paragraph 3.116 onwards). In summary, we consider that the benefits of delay on this account are unlikely to be significant. In part, this is because prospective bidders at auction will always face uncertainty whenever the auction is held, and there are no strong grounds to believe that the aggregate level of uncertainty will dramatically reduce if we were to delay the award for a given amount of time. In addition, it is because the licences will be tradable and, where one entity turns out to have the ability to generate much more value from use of the spectrum than the entity that won spectrum through the auction, then there would be a strong incentive for trading to take place and, at least partially, redress any significant imbalance in allocation arising from the primary award.

[34] E.g. T Hazlett and R Muñoz, A welfare analysis of spectrum allocation policies, George Mason Law & Economics Research Paper No. 06-28 (April 7, 2006); J. Ellig, Costs and Consequences of Federal Telecommunications and Broadband Regulations, (2005) George Mason University Working Paper in Regulatory Studies http://mercatus.org/pdf/materials/1074.pdf

Responses to the December 2006 Consultation and the Discussion Document

3.116 All of the respondents to the December 2006 Consultation agreed, in principle, that the 2.6 GHz and 2010 MHz bands should be awarded, that they should be licensed and (with the exception of 1 out of 35 responses) that an auction was the most suitable process for the award.

3.117 However, respondents to the December 2006 Consultation disagreed over the timing of the award of the 2.6 GHz band and, where an opinion was expressed on this issue, the responses (both presented in writing and in meetings) fell into two broad categories:

- the view held by those associated with the use of WiMAX technology (such as potential service providers and equipment manufacturers) was that **the award should take place as soon as possible**; and

- the view held by most of the 3G MNOs and 3G equipment manufacturers was that **the award should be delayed**.

Responses arguing for the award of the band as soon as possible

3.118 Respondents who were in favour of awarding the band as soon as possible (including BT, Intel, Siemens, Sprint Nextel, the WiMAX Forum and the UMTS Forum) argued that:

i) there was an immediate need for the spectrum for operators to serve a large market of end-user demand that they had identified for mobile broadband services;

ii) the spectrum was available and could be used for new and innovative uses in the near future, equipment was available now and further equipment was expected to become available in the near future;

iii) there were clear examples of substantial investments for innovative services in large markets for mobile use at 2.6 GHz, such as with Sprint Nextel in the USA or Korea Telecom in South Korea;

iv) the UK would otherwise lag behind other European countries which have announced awards of the 2.6 GHz band in late 2007 and early 2008;

v) a timely award in the UK would stimulate market dynamics in Europe with a beneficial impact on equipment volumes and prices, which could be passed onto service providers and consumers; and

vi) the window of opportunity for new mobile broadband service providers to enter the market is relatively narrow and a material delay could see the establishment of substantial barriers to entry for new entrants[35].

3.119 In response to the Discussion Document, the respondents in favour of awarding the band now, maintained the view that the 2.6 GHz band should be awarded as soon as possible.

[35] For example, if the 3G operators were able to cement their incumbency advantages and establish evolutions of 3G technology as the dominant platform for mobile data.

Responses arguing for a delay to the award

3.120 In contrast, those who argued that the award should be delayed, in particular the existing MNOs (to varying degrees), identified regulatory uncertainties as the main reason for delaying the award, namely that

- mobile spectrum liberalisation (i.e. liberalisation of 2G spectrum at 900 MHz and 1800 MHz, and of 3G spectrum at 2.1 GHz) only affects one group of potential participants in the award, i.e. the MNOs, and that to proceed now would therefore be inefficient and would distort competition[36]; and

- as part of this concern about the uncertainty relating to their bidding now in the award, they argued that to proceed with the award now, given the uncertainties that solely affect the MNOs, would discriminate against them.

3.121 Some MNOs also argued that we should delay the award until there was clarity in relation to any potential RSC Decision relating to the 2.6GHz band.

3.122 We note that there were differences of opinion over how regulatory uncertainty could sufficiently be reduced and what type of delay this could mean for the award. For example, while Vodafone considered that the uncertainties relating to 2G liberalisation should be resolved before any award of the 2.6 GHz frequencies it did not consider that this should necessarily result in a delay to the award. Orange similarly thought that clarity over liberalisation of 2G spectrum including changes in allocation (if any) could be provided without substantial delay to the award. On the other hand T-Mobile claimed that the issue of reallocating 900 MHz spectrum had to be resolved before the auction could proceed.

3.123 There were also differences of approach between the MNOs on which uncertainties were relevant. The four 2G MNOs focused mainly on regulatory uncertainty, in particular over the liberalisation of 2G spectrum. H3G, on the other hand, was also concerned about technology and market uncertainty[37].

3.124 Some of the MNOs also argued that demand for use of the 2.6 GHz band was unproven, or that the December 2006 Consultation did not provide sufficient proof that demand exists. Vodafone did not address the question of demand in its response.

3.125 In addition to the arguments mentioned above concerning uncertainty over mobile spectrum liberalisation and the RSC Decision which covers the 2.6 GHz band, those arguing for a delay to the award, including several of the MNOs, raised further issues, referring to:

a) technology and market uncertainties (for example, surrounding future technologies such as LTE[38] and IMT-Advanced[39] and the associated end-user demand that would drive their introduction);

[36] MNOs argued that it would be more difficult for them to value the spectrum than others, not affected by uncertainty over 2G liberalisation, which could impair the efficiency of the auction.
[37] Some manufacturers also argued that the award should not take place until LTE standards were agreed.
[38] Long Term Evolution, a term covering the potential next generation of cellular mobile technologies in the 3GPP UMTS family and likely to require spectrum in blocks of 2x10 or 2x20 MHz if used at 2.6 GHz

b) other regulatory uncertainties that are relevant to potential demand for 2.6 GHz spectrum and which could be addressed over time such as:

   - liberalisation of 3G TDD spectrum (as this would increase the scope for use of this licensed spectrum, which could be linked to the 2.6 GHz band);
   - availability of other substitutes for the 2.6 GHz band such as DDR spectrum;

c) the need to resolve technical interference issues and the treatment of adjacencies between different types of user;

d) the immaturity of the spectrum usage rights (SUR) concept and concerns over their application, the consideration of which would require a delay to the award;

e) novel and untested features of the auction design (with the observation that the 2.6 GHz auction design should be finalised only after the 10-40 GHz award, in which a similar design is planned, has taken place);

f) claims that legitimate expectations existed, arising from the 3G licence auction in 2000, that the 2.6 GHz band would be reserved for use as a 3G expansion band (and that the award should not take place until the there was demand for use by 3G technologies and / or by 3G licensees); and

g) uncertainties over legal restrictions on third party use of spectrum arising out of the ongoing appeals in the Floe Telecom and VIP cases.

3.126 The MNOs' responses to the Discussion Document were mixed. For example, O2 argued that coterminous decisions on the award of 2.6 GHz and 2G and 3G liberalisation were vitally important. Orange noted that the mobile spectrum liberalisation consultation was not sufficient for MNOs to rely on in their planning for the 2.6 GHz auction. They also suggested that technology uncertainty could affect MNOs more than other potential bidders because WiMAX was available sooner, but admitted that this would be a difficult judgement for us to make. Vodafone did not make any specific comment on the timing of the award. In this regard we note that we have, where relevant, taken account in this document of the responses which we received to the consultation on mobile spectrum liberalisation.

3.127 The following sections discuss the key concerns which have been raised against awarding the 2.6 GHz band as soon as possible.

Will uncertainty lead to inefficient use of spectrum if the 2.6 GHz band is awarded as soon as possible?

Our consideration of the arguments put forward for delaying the award

3.128 As outlined in the previous section, the MNOs and a small number of other stakeholders have argued that rather than following our usual practice of making spectrum that is not being used available to the market, and doing so now, we should delay the award. However, a clear proposition as to how long the delay should be, or what conditions should trigger a decision to hold the award in future, does not

[39] A family of future mobile and nomadic broadband standards currently under consideration in ITU. Potentially able to support data rates up to approximately 100 Mbit/s in the mobile environment and 1Gbit/s in the nomadic environment. IMT-Advanced was formerly known as systems beyond IMT-2000 – see Recommendation ITU-R M.1645 for further information.

emerge from these responses. Moreover, although the principal source of uncertainty which has been raised concerns mobile spectrum liberalisation, views diverge on what other sources of uncertainty might be relevant to a decision to delay the award, including the need to take account of the experience holding of the 10-40 GHz award[40] and uncertainties over legal restrictions on third party use of spectrum linked to the Floe Telecom case[41].

3.129 The general thrust of the MNOs' argument appears to be as follows:

- delaying the award to a point when the uncertainty associated with mobile spectrum liberalisation would be greatly reduced would allow MNOs to make more informed valuations for 2.6 GHz spectrum; and
- as a consequence, this would result in an award outcome that was more efficient (in terms of spectrum being assigned to those who value it most) than if the award was held earlier.

3.130 We therefore consider below the costs, benefits and risks of such an approach in light of our statutory duties, and discuss in turn each of the following:

- the materiality of the uncertainty surrounding mobile spectrum liberalisation and the impact this could have on valuations of 2.6 GHz spectrum, including;
  - the nature of the current uncertainty surrounding liberalisation of mobile spectrum; and
  - the significance of mobile spectrum liberalisation uncertainty to the 2.6 GHz award;
- the scope for spectrum trading to facilitate a reallocation of 2.6 GHz spectrum over time and so mitigate the impact of any sub-optimal outcome to the initial award (if that turned out to be the case); and
- conclusions on the resulting implications for the impact of mobile spectrum liberalisation uncertainty for the 2.6 GHz award.

3.131 We note that on 2 April 2008, Member States agreed the text of the RSC Decision relating to the 2.6GHz band, which had been pending during our consultation periods. We therefore consider that this potential head of uncertainty has been removed, and so do not consider further the arguments put to us in some consultation responses that we should wait until a decision had been agreed.

[40] Some MNOs argued that we should wait until parties have had a chance to digest the lessons that can be learned from the 10-40GHz auction before making decisions on this award, since the 10-40GHz auction shares a similar (though not identical) auction design with that proposed for 2.6GHz. The 10-40GHz auction was completed on 22 February 2008 and we have obtained feedback from stakeholders and received a review of the auction by our external auction advisers. Although there are some helpful lessons that we will take on board, as explained in Section 7, the 10-40GHz auction appears to have been very successful. We consider that parties who participated in that auction, and who may be contemplating participating in this award, will have ample time to take account of the 10-40GHz auction before this award takes place

[41] We do not consider that the Floe case is a significant issue in relation to this award. First, T-Mobile, who raised this issue and who are involved in the case, are able to participate in this award regardless of the outcome of the Floe case, and second, the judgment of the Court of Appeal in the Floe case is likely to be available well before the commencement of this award process.

Is uncertainty over mobile spectrum liberalisation likely to have a material effect on the 2.6 GHz award?

The nature of uncertainty over mobile spectrum liberalisation

3.132 Those MNOs which have argued that we should delay the award consider that there is a level of uncertainty affecting their valuation of 2.6 GHz spectrum, which can and should be resolved in order to ensure an efficient award. They argue that failure to do so would disadvantage them with respect to other potential bidders, who do not face the same uncertainties, when making their valuations.

3.133 The potential impact of mobile spectrum liberalisation on MNOs' and other bidders' valuations of 2.6 GHz spectrum will depend on:

- **choice of technology:** the flexibility licensees will have to deploy alternative technologies in spectrum currently licensed for 2G or 3G use;
- **spectrum holdings:** the quantity of spectrum that each party has rights to use in the future.

3.134 Our position is clear on the first point. The RSC decision on 900 MHz and 1800 MHz[42] requires us to make this spectrum available for 3G use within a reasonable time period, and permits us to make it available for other terrestrial systems. In respect of the 2.1 GHz band, the pending RSC Decision does not impose obligations on the UK. We have, however, proposed in the mobile spectrum liberalisation consultation that existing restrictions on the use of alternative technologies in this band would also be removed. We consider that there is therefore relatively little uncertainty over the future flexibility to deploy alternative technologies in these bands in principle, although we acknowledge that this will depend in practice on the timing of implementation of the RSC decision on 900/1800 MHz.

3.135 On the second point, in contrast, we consider that uncertainty over future holdings of 900 MHz and 1800 MHz will not be fully removed until the method of implementing liberalisation has been chosen and put into effect. For example, were we to decide that one of the requirements for liberalising 900 MHz was that Vodafone and O2 must release some of their 900 MHz holdings to others, certainty as to future holdings would not be achieved until after the award of the released spectrum (even then, holdings of 2G spectrum would be subject to change because the spectrum is expected to be tradable).

3.136 We published the mobile spectrum liberalisation consultation in September 2007 with a view to moving towards a consensus on the costs and benefits of the options for liberalisation and narrowing the range of feasible options. However, considerable disparities in the MNOs' views still remain on those costs and benefits as well as the potential implementation options for liberalising 900 MHz and 1800 MHz spectrum. This significant lack of consensus makes it less likely that we will be able quickly to resolve the issues and implement mobile spectrum liberalisation in the near future.

3.137 Our intention remains to progress these issues as quickly as possible, although we acknowledge that resolving the complex issues around mobile spectrum liberalisation is likely to take time, and could involve further stages (including more evidence gathering, analysis and consultation) in our decision making process. Whilst the

[42] The decision will come into force after Council Directive 87/372/EEC of 25 June 1987, OJ L 196, 17.7.1987, p.85 (the GSM Directive) is repealed.

source of this uncertainty is largely regulatory in nature, the views and input of the relevant stakeholders are of significant importance. As highlighted above, those views currently diverge widely from each other.

3.138 In relation to the 2.1 GHz band, we have made no proposals for regulatory action which would affect the current distribution of holdings other than the extension of trading to the band. We intend, as discussed in Section 4, to deal with the issue of the tenure of the current 3G licences at an appropriate date in the future, in light of our statutory duties.

The significance of uncertainties over mobile spectrum liberalisation for valuing 2.6 GHz

3.139 In this subsection we examine the significance of uncertainty over liberalisation of 2G spectrum for valuations of 2.6 GHz spectrum if everything else is assumed to be held constant. There are two types of potential impact. The first relates to whether the outcome of mobile spectrum liberalisation will affect the level of competition in the provision of mobile services. The second concerns the degree to which 2G spectrum and 2.6 GHz spectrum may be substitutes for each other.

3.140 If the outcome of mobile spectrum liberalisation were to affect the level of competition in the provision of mobile services, then this could influence the values that all types of bidder attribute to services that they might look to provide using 2.6 GHz spectrum. However, all bidders are in possession of similar information in this regard. We have made it clear that we expect this spectrum to be liberalised in due course and we would expect all bidders to factor this development into their considerations. We have also indicated that competition considerations will be an important determinant, along with others, over the way that the spectrum is liberalised. The uncertainties principally concern the precise manner and timing of any reassignment of spectrum holdings that might accompany the liberalisation of 2G spectrum. However, this is only one factor (of many) that could influence future levels of competition in the provision of mobile services. We do not consider it is correct to single out this one factor as being the dominant source of uncertainty in this regard and, therefore, to argue that this factor is a key uncertainty for 2.6 GHz valuations.

3.141 Turning to the second issue, the significance of uncertainty over 2G liberalisation also depends on the degree to which 2G spectrum and 2.6 GHz spectrum may be substitutes for each other, taking account of:

a) the impact of physical characteristics of those frequencies, such as propagation characteristics, on the feasibility and costs of deploying services;

b) practical constraints and costs involved in changing the use of existing spectrum holdings which may be carrying other services; and

c) the time at which different technologies might become available for deployment in different bands, depending on technology standards and equipment availability.

3.142 In principle, operators could consider 2.6 GHz and 2G spectrum as substitutes for:

a) providing coverage for existing services (principally 3G);

b) enabling deployment of new technology layers; or

c) providing incremental capacity for existing services.

3.143 New entrants might also consider 2.6 GHz and 2G spectrum as substitutes for rolling out new networks.

3.144 **Coverage.** In practice, we consider that, for providing coverage for existing MNO services, 2.6 GHz spectrum is unlikely to be a realistic substitute for 2G spectrum. This is because the five MNOs have already deployed 3G networks using the 2.1 GHz band, and have achieved substantial coverage levels. If they planned to increase their geographical coverage, it is unlikely that they would use 2.6 GHz spectrum instead of 2.1 GHz spectrum because of the poorer propagation characteristics of 2.6 GHz.

3.145 Moreover, 900 MHz (and to a lesser extent 1800 MHz) may have significant advantages over both 2.1 GHz and 2.6 GHz in providing in-building coverage and we consider that it is plausible that MNOs could decide to deploy these bands to improve the indoor coverage of their existing 3G networks. We are currently updating the initial view we put forward in the mobile spectrum liberalisation consultation that this was the case, following the wide range of responses we received on these points.

3.146 Irrespective of the outcome of this further work on the relative properties of the 2.6 GHz and the 2G spectrum for coverage, given the relative disadvantage of 2.6 GHz versus 2.1 GHz spectrum mentioned above, MNOs' valuations of 2.6 GHz spectrum are more likely to depend on the following two uses:

a) enabling the deployment of new technology, in particular to deliver high rate mobile broadband services by exploiting the large amounts of spectrum available in the 2.6 GHz band which make it possible to use large channel widths (2x10 MHz or 2x20 MHz) compared to those in use now for 3G (2x5 MHz). The MNOs' responses suggest that it is more likely that they would use the LTE standard when this is available than the WiMAX standard although the latter was not discounted as an option by some MNOs; and / or

b) adding incremental capacity either for 3G networks (which use 2x5 MHz paired spectrum) or for future LTE networks. We note that if MNOs were able to, and chose to deploy an LTE layer at 900 MHz it is likely that variable channel widths from 1.25 MHz upwards could be accommodated. However, operators could probably deliver significantly different services using LTE over 2x20 MHz from those they could deliver using LTE over 2x1.25 MHz. The wider channel widths would allow operators to offer substantially higher functionality, i.e. considerably faster end user data rates.

3.147 **New technology layers.** If an MNO wanted to deliver high rate mobile broadband services using wide channel widths, the substitutability of 900 MHz spectrum for 2.6 GHz spectrum appears weak because it is very unlikely that any one MNO is likely to have access to cleared 900 MHz spectrum in similar channel widths - there is a total of 2x34.4 MHz of spectrum available for mobile use in the 900 MHz band, and two operators are currently providing services to consumers using this spectrum.

3.148 The substitutability of 1800 MHz with 2.6 GHz for this purpose may be greater than that of 900 MHz, though it still appears limited in the short to medium term at least. 2x71.6 MHz is available in the 1800 MHz band and currently four operators are providing services to consumers using this spectrum. Even if some spectrum could be cleared of existing 2G use in the short term, it would clearly take a significant period of time to make the majority of the spectrum available for services requiring wide channels. Moreover, uncertainties remain regarding when LTE equipment will be available commercially for 900 and 1800 MHz spectrum. Hence, if the MNOs wish

to deploy a wide-channel LTE layer in addition to their existing networks in the medium term then neither the 900 MHz band nor the 1800 MHz band may offer a viable alternative to 2.6 GHz spectrum.

3.149 **Incremental capacity for existing services.** If an MNO wanted to provide additional capacity for services delivered over 3G (or even LTE), there are many different options open to them. We consider that the cost of providing additional capacity together with *good indoor coverage* is likely to be materially lower using low frequency spectrum. However, focusing purely on the issue of increasing capacity (without considering indoor coverage properties), some or all of the following options could all be applied to existing 2.1 GHz networks:

a) cell splitting i.e. adding another base station to cover the area previously covered by one base station. A doubling of macro cell density would more or less double capacity, although site acquisition (to the extent that new sites are required) can become increasingly difficult as site density increases;

b) adding an outdoor layer of smaller cells (such as micro, mini, picocells) would increase capacity. In 3G networks, these techniques have not been employed to any great extent to date;

c) deployment of femtocells; studies suggests that this could reduce the demand for capacity on a macrocell network by up to 70%[43] (though only in the locations where consumers have installed them, not universally across the network);

d) increasing the sectorisation of macrocells, i.e. increasing the number of sectors into which every cell is split by adding more antennae. For example going from three to six sectors per site would lead to roughly an 80% increase in capacity; and

e) increasing power might increase capacity by perhaps 50%.

3.150 These factors taken together might increase the effective traffic carrying capacity of a 2.1 GHz network by approximately 500-1000% compared to a 3G roll-out using, for example, two carriers and three sector cells. We note that outdoor microcells are seldom currently used nor are six sector macrocells (indeed some are still omni-sector). There has been a trend to increasing power but there is potentially still more scope to do this. In addition, a wider adoption and roll-out of enhanced 3G technologies, notably HSPA, will increase the data carrying capacity of a given network design e.g. currently MNOs are deploying or planning to provide maximum download speeds of 3.6Mbit/s whereas 14.4Mbit/s or higher may be possible in the future. A very high level analysis of potential 3G demand suggests that the above options might be sufficient to deal with traffic growth for the short term.

3.151 In addition, MNOs may have further options for expanding 3G capacity when other spectrum bands, such as the 2G bands or DDR spectrum, become available. These may be more cost effective than using 2.6 GHz spectrum for increasing capacity depending on MNOs' network deployment strategies, for example part of the rationale for deploying 900 or 1800 MHz spectrum for 3G use may be to improve indoor coverage of 3G services.

[43] For example, "3G Network Evolution from 2007 to 2012: HSPA+, LTE, WiMAX and femtocells" Analysys Research, 2008

3.152 Hence, MNOs have a number of options for adding to their 3G capacity of which deploying 2.6 GHz is just one. Deploying 2.6 GHz involves not only set-up costs and upgrading of base station sites (some of which is common to other options), but also a requirement for an adequate take-up of compatible handsets. Where the costs of two alternatives are closely matched, this may be decisive in making one option cheaper. It is therefore possible that other options may be more cost effective than deploying 2.6 GHz. The net benefit will also depend on wider MNO strategies, developments in handsets and the cost of migrating subscribers to new handsets.

3.153 2.6 GHz does not therefore appear to be the most important short or medium term option for the MNOs to add 3G network capacity. Moreover, it seems unlikely that failing to get access to 2.6 GHz would deny MNOs the opportunity to develop 3G services, because other options would be available and may even be preferable.

3.154 In our discussions with MNOs some felt unable to express any view on how they saw 2.6 GHz fitting within their network development plans ("too early to give a view"). Those that did, implied that their main interest would probably be for LTE (or possibly WiMAX) and that, for LTE, larger channel widths would be an important factor in their valuation of 2.6 GHz.

3.155 In conclusion, whilst there are some limited scenarios in which there is substitutability between 2.6 GHz and 2G spectrum, such as the potential flexibility in carrying high data rate traffic on 3G and LTE networks and as one of several options for expanding 3G capacity, we do not consider that the substitutability is as material as some MNOs have argued.

Implications of uncertainty over 2G liberalisation for the award of the 2.6 GHz band

3.156 Future demand for 2.6 GHz spectrum depends on a range of market, technology and regulatory factors which are continually evolving. Bidders will always face uncertainty regardless of when an award takes place. The existence of uncertainty is not, of itself, a reason to delay an award. Hence, we need to assess whether the nature of the uncertainty relating to mobile spectrum liberalisation is such that it:

a) is significantly greater as a source of potential (non-transitory) inefficiency in the award than other sources of uncertainty with regard to bidder valuations of 2.6 GHz; and

b) is different to other uncertainties in terms of being fully within our control to remove it.

3.157 Whilst MNOs have placed emphasis on the specific uncertainty concerning mobile spectrum liberalisation, we consider that other uncertainties relating to a wide range of market, technology and regulatory conditions are likely to have a greater influence, in aggregate, on valuations of 2.6 GHz spectrum. Examples of other sources of uncertainty include the following:

- future demand for mobile broadband services - the variation in mobile traffic demand scenarios used in the modelling which underpinned our review of Mobile Call Termination ranged between 300 to 450% depending on the year;

- development of technology including, for example, femto-cells and the pace of LTE development and the range of frequencies over which these might become available.

- release of other spectrum such as:
    - the DDR spectrum award in which 120 MHz of very valuable low frequency spectrum is available (with potentially 2 x 25 MHz in a band that may available across a number of EU Member States);
    - the Complementary Ground Component for MSS satellite services - where 2 x 30 MHz is available around the 2 GHz frequencies;
    - spectrum that may be released as a result of the Independent Audit of Spectrum Holdings, led by Professor Martin Cave, for example in the 2.7-2.9 GHz range;
- developments in network sharing and impact on network capacity requirements; and
- the possibility of changes in market structure (e.g. resulting from M&A activity) which may affect end-user demand per operator and prices.

3.158 Of course, it will always be desirable to remove sources of uncertainty where we have the unfettered ability to do so. Even if an uncertainty is likely to have only a modest influence on overall valuations, its removal will still represent an improvement for bidders and, if this translates into a more efficient award outcome, then this could translate into consumer benefits. However, we have explained above that the implementation method for mobile spectrum liberalisation is unlikely to be resolved in the short term, nor do we yet know when a solution will be arrived at. In any case, the full resolution of the uncertainty connected with mobile spectrum liberalisation will require a knowledge of which parties will hold what amounts of spectrum following the final implementation of the approach which is eventually adopted. If that approach involves an auction of any released spectrum then the outcome of any such auction will clearly not be known in advance.

3.159 In understanding the impact of uncertainty, it is important to be clear that MNOs and other potential users of the spectrum regularly have to make significant business decisions whilst important factors remain uncertain. For example businesses have to take into account market demand, changes in technology, development of new services, and competitor strategy which are constantly evolving over time. There will never be a point in the future when all uncertainties affecting potential participants in the award will be removed. As some factors become more certain, new uncertainties are very likely to arise.

3.160 Uncertainties for this and other spectrum awards are numerous and varied in nature. Stakeholders may face different uncertainties or be affected by the same uncertainties to different extents because of their individual circumstances. However, it is clear that all potential participants in any spectrum award will face a number of uncertainties (including the availability of other spectrum bands), regardless of when the award takes place.

3.161 We note that other potential users of the 2.6 GHz bands, who are requesting that the award takes place as soon as possible, also face a range of uncertainties as do all other potential bidders in the award. These include uncertainties affecting their own competitive position such as future access to spectrum, technology development, and the impact of potential changes in the MNOs' spectrum holdings (e.g. as a result of mobile spectrum liberalisation, other spectrum awards or spectrum trading).

3.162 As a general rule, we consider that potential service providers are much better placed than the regulator to assess the impact of uncertainties relating to 2.6 GHz spectrum – both on themselves and on other market participants - in order to estimate the value of the spectrum in its alternative uses. We note that, by proceeding with the award as soon as possible in the face of existing uncertainty, we would be allowing all interested parties to decide whether to participate in the award and how best to make use of the spectrum.

3.163 In contrast, we are less well placed than the market to assess the risk associated with delaying the award given the range of potential uncertainties. As a result, we would need strong evidence that awarding the spectrum as soon as practical would lead to a worse outcome for consumers in order to justify delaying the award. We have not seen evidence to this effect.

Relevance of post-award trading

3.164 The risk discussed above is that the existence of a specific, temporary uncertainty might mean that a delayed award would lead to a more efficient allocation of the spectrum than an earlier award (more efficient in the sense that the spectrum is allocated to parties who can create greater value from its use). However, this risk can be mitigated by the ability to trade the spectrum holdings after the award. At the limits, if the ability to trade were frictionless then any inefficiency in the primary award would be capable of being fully corrected and there need be no dilution of benefits to consumers in terms of the services they are offered using the 2.6 GHz band.

3.165 Of course, the ability to trade is not frictionless. But, if the primary award led to an outcome that turned out to be significantly less efficient (in the sense that the value to the acquirers of spectrum in the primary award turned out to be significantly below the value that another group, with an alternative use, subsequently came to attach to it) then the differential in the revised commercial valuations would make these trades much more likely to take place. In other words, the less efficient the primary allocation, the stronger the incentives for trading to take place and the more likely that the inefficiency, and hence the potential loss in consumer benefit, will be mitigated by trading.

3.166 Some respondents suggested that trading of 2.6 GHz spectrum would be difficult to achieve, particularly if the operator wishing to acquire the spectrum wanted to change its use from TDD to FDD. If so, then there would be a limit on how effectively trading could mitigate the effect of any inefficiency in the primary award that emerged over time.

3.167 Any consideration of the degree to which trading could provide an effective correction needs to recognise the particular types of trade that would be required and the circumstances surrounding the primary award that could give rise to the need for this type of trade.

3.168 In this regard we note the following.

i) **Paired-to-paired trades:** there should be no technical barriers to the trading of paired (FDD) spectrum from one user to another user that (also) intends to use it for paired technology (and no need to change the technical licence conditions).

ii) **Paired-to-unpaired trades:** there should be no particular difficulty in taking spectrum that has technical conditions applicable to paired use and turning it into spectrum with usage rights appropriate for unpaired use. However, depending on

where the particular frequencies of the blocks and their position within the 2.6 GHz band, the acquiring user would need to set some blocks aside for guard bands (or rather, blocks with restricted usage rights as explained in section 5). However, this need not lead to any loss in spectrum efficiency, or in ultimate benefits to consumers (unless the spectrum is in the middle of the FDD range as, in this case, two additional 5 MHz blocks would need to be set aside).

iii) **Unpaired-to-paired trades:** a similar set of considerations apply as in ii) above, in that the acquiring user would need to set some blocks aside for guard bands (or rather, blocks with restricted usage rights) but this need not lead to any loss of efficiency by comparison with a situation in which the same pattern of spectrum ownership had occurred in the primary award. However, the acquiring user would need to buy unpaired spectrum that is separated by 120 MHz and this could require it to transact with two or more holders of unpaired spectrum. We agree that this could be more complicated to achieve. However, as noted above, if the change in valuations over time of paired and unpaired spectrum are substantial, then the value that can be created though trading make it much more likely that trading will occur, the above challenge notwithstanding (and if the changes in valuations are not substantial, then the cost to consumers of the trades not happening will be less significant).

3.169 The above analysis suggests that the ability to trade post-award should provide significant scope to mitigate the effects of an outcome in the primary award that turned out, over time, to be less than fully efficient. Moreover, the greater the departure from a fully efficient allocation, the greater the incentive for corrective trading to take place.

3.170 Some respondents suggested in their response to the Discussion Document that the outcome of the award of 2.6 GHz would be “irreversible” which implies that there would be insurmountable barriers to acquiring a paired allocation of spectrum by trading with holders of unpaired spectrum. They argued that this represented a risk of proceeding to award the band as soon as possible. This depends on the following arguments:

a) spectrum might be awarded inefficiently to users of TDD or WiMAX systems at the expense of users of FDD systems;

b) once spectrum has been awarded for unpaired use it cannot be reallocated to form a paired allocation of spectrum; and/or

c) transaction costs would be so high as to create a barrier to trading of 2.6 GHz spectrum.

3.171 On the basis of our analysis above we disagree with the suggestion that spectrum trading in the context of the 2.6 GHz band would have no power to mitigate the risk of an inefficient outcome arising. Further, if it appeared in future that spectrum markets were not functioning efficiently, we could take action to address the issue[44]. As a result we do not consider that holding the award as soon as possible would lead to an irreversible situation in which the MNOs were prevented from accessing spectrum in the future. We also note that a later award could bias the award against unpaired spectrum use if delay closes the window of opportunity for entry by providers using TDD systems, such as WiMAX.

[44] See the Spectrum Framework Review Statement of June 2005 and in particular the discussion of market failures in section 4.5 for more information (http://www.ofcom.org.uk/consult/condocs/sfr/sfr/).

Conclusions on the impact of mobile spectrum liberalisation uncertainty on the award of the 2.6 GHz band

3.172 Any decision as to the timing of the award will carry some risk:

a) if the spectrum is awarded as soon as possible, there is always a potential risk of an outcome to the award which turns out, in time, not to represent the highest value allocation of spectrum - for example, if an MNO finds at some future date that it could generate greater benefits from using spectrum (or a part thereof) acquired by a non-MNO bidder (even after taking account of its later starting date for using the spectrum) and the MNO is unable to secure the spectrum through the secondary market despite valuing the spectrum more. However, we consider this risk is low;

b) if the award is delayed, there are risks that we consider more likely: firms could be denied the opportunity to enter the market; innovation may be delayed or may not occur at all; the UK may fall behind other countries in mobile broadband development; uncertainties may not be reduced in the near term or may be replaced by further sources of uncertainty. Additionally, the spectrum will remain underused for the period of postponement.

3.173 As we set out at the beginning of this section, we consider that the risks that uncertainty associated with mobile spectrum liberalisation create for an award of the spectrum as soon as possible are low, for the following reasons:

i) uncertainty itself should not lead to an inefficient award because bidders will bid on the basis of their expectations about future events;

ii) although uncertainty over mobile spectrum liberalisation may affect potential bidders asymmetrically (and this is not certain), this is no different in principle from other sources of uncertainty. Moreover, the significance of this uncertainty for valuation of 2.6 GHz is relatively low because (a) 2G spectrum and 2.6 GHz spectrum are unlikely to be close substitutes for each other and (b) it is only one of many sources of uncertainty which bidders would have to take into account in an auction and with which they have to deal in the course of their normal business activities;

iii) delaying the award will not eliminate uncertainty, because other uncertainties are bound to appear, whether in terms of technology or market uncertainties or new regulatory issues;

iv) the auction is designed to assist price discovery, thus levelling the playing field with regard to uncertainties that affect all bidders; and

v) we consider that trading, coupled with technology neutrality, can mitigate the limited potential risk associated with awarding the spectrum as soon as possible.

3.174 The risks of delaying the award are very much more material because there is real and urgent demand for this spectrum and may be a limited window of opportunity for entry. Delaying the award would bias the award against new entrants, and we note that within this time frame there appears to be little alternative for players wanting to introduce and use WiMAX to provide mobile services.

3.175 We consider that the risks associated with delay are likely to be much more significant than those associated with awarding the spectrum as soon as possible, in particular when considering how the risks relate to our statutory duties:

a) **Acting in the interests of consumers by promoting competition:** a decision to delay carries a substantial risk of detrimentally affecting consumers by delaying, and possibly preventing, competition, and so reducing the economic benefits that could be derived from the 2.6 GHz band. There is a clear risk that regulatory action to delay the award would conflict with our duties regarding the promotion of competition by, in effect, creating conditions in which our actions denied the opportunity for new competition.

b) **Securing optimal use of the spectrum:** delay (by keeping the spectrum under-used) is unlikely to be consistent with the requirement to secure optimal use of the spectrum and promoting the efficient use and management of the spectrum. We consider that the market is better placed to assess uncertainties and to bring about more efficient outcomes than if the regulator effectively decides how the spectrum should be used. In addition spectrum trading can alleviate any residual concerns over efficiency after the initial award of the spectrum.

c) **Promoting innovation:** in having regard to the demand for use of spectrum and demand that is likely to arise in future, we are particularly mindful of the risk that the window of opportunity for new service providers to establish themselves, employing new technologies, would be likely to disappear if we delayed the award. By awarding the spectrum as soon as possible, we would be removing or reducing that risk by offering all interested parties the opportunity to participate.

3.176 Some existing MNOs have argued that we should not proceed now as the uncertainties surrounding mobile spectrum liberalisation would affect them more than they would other bidders and that a decision to proceed with the 2.6 GHz award before resolving mobile spectrum liberalisation would therefore be discriminatory, as it would put them at a disadvantage compared to other bidders.

3.177 In fact, as discussed above, we consider that all bidders will be affected to varying degrees by uncertainty over mobile spectrum liberalisation and by many other uncertainties. However, not every bidder will be affected in the same way and it would be impossible to achieve a situation where all bidders' valuations were equally affected by uncertainty at any point in time. It is possible that a decision to delay the award until such time as the MNOs' uncertainty over mobile spectrum liberalisation was reduced or removed could discriminate against those stakeholders who have expressed an interest in using the spectrum as soon as possible.

3.178 In a situation where different stakeholders have differing objectives and considerations, we consider that we should proceed in a manner which best meets our statutory objectives and as far as possible seek to minimise any differential effects on stakeholders which may result. In this particular case, where one group of stakeholders is arguing for delay, and another group is arguing in favour of holding the award as soon as possible, it is inevitable that our conclusion on when to proceed with the award will affect one group differently from the other. However, we do not consider that one group of stakeholders is discriminated against by a decision to proceed with the award as soon as possible.

3.179 There are a number of reasons to support this conclusion. First, the limited window of opportunity for new entrants is an immediate issue: delaying the award may remove this competitive window absolutely. Conversely, MNOs would have the

option of participating in the award now with a view to using the spectrum at a later date. Proceeding with the award would not therefore preclude the MNOs from being able to access the spectrum at a time when they consider they need it. The set of options open to existing MNOs is further widened by trading, which means that MNOs could choose to seek to acquire spectrum not in the auction but subsequently in the secondary market.

3.180 Second, our analysis shows that uncertainty over mobile spectrum liberalisation is unlikely to be dominant in the context of the other uncertainties which bidders in the auction face and in the context of the uncertainties with which they manage in the normal course of business activity. Therefore, the MNOs are unlikely to be particularly disadvantaged by awarding the spectrum as soon as possible. Respondents who have expressed a clear interest to use the spectrum to develop new services and technologies are however likely to be significantly disadvantaged by any material delay.

3.181 In light of the fact that it is our usual practice to make spectrum available when it is unused, and the evidence of demand which we have received, we have decided to proceed to award the spectrum as soon as possible. However, given the responses which we received from stakeholders arguing in favour of delay, we have considered the costs and benefits of proceeding with an award now. We have concluded that the benefits of proceeding outweigh the costs of proceeding and the benefits of delaying. For the reasons set out above, we do not believe that our decision to proceed with the award as soon as possible, based on the evidence underlying our cost/benefit analysis, unduly discriminates against those stakeholders in favour of delay, particularly in light of the fact that they are not precluded by our decision from participating in the award.

Alternative proposal to award only part of the 2.6 GHz band now

3.182 One respondent proposed in a confidential response that only the centre 50 MHz be awarded at this point, and that remaining 140 MHz be awarded at a later date when some of the uncertainties have been reduced. It argued that this approach would:

- allow some entry into the market by players operating TDD systems in the 2.6 GHz band which, along with potential mobile WiMAX use in 3.5 GHz band, would deliver most of the competition and innovation benefits that we outlined in the Discussion Document;

- allow the remaining 140 MHz to be subject to an award at a later date after mobile spectrum liberalisation (and other relevant uncertainties) had been resolved, thereby leading to a more efficient award.

3.183 In summary, we do not consider that this proposed alternative approach would achieve the same level of benefits as an award as soon as possible of the whole of the band.

3.184 Equally, a similar set of considerations as set out in the preceding paragraphs in relation to uncertainty would apply to the subsequent award of the remaining 140 MHz of spectrum, including questions relating to when stakeholders would consider that the uncertainty relating to mobile spectrum liberalisation had been resolved to their satisfaction. Assuming it was possible to overcome this, the proposal has other significant drawbacks compared to awarding of the whole band as soon as possible, as outlined below.

Our concerns with the proposal relating to market entry, competition and innovation

3.185 We consider that the potential for entry would be limited under this alternative option. The respondent argued that WiMAX could be deployed with a total of 10 or 20 MHz channels, quoting a WiMAX Forum paper[45], and therefore argued that 50 MHz would be enough to allow several new entrants. In fact the WiMAX Forum paper subsequently goes on to state that it would be substantially more expensive to roll out a network on this basis[46] and states that a minimum requirement of 30 MHz would be needed to realise the full potential of mobile WiMAX[47]. This is also consistent with the indications which we have received in confidence from several interested parties.

3.186 Hence, given that only 40 MHz of usable spectrum would be available, because of guard bands or restrictions on use of lots at the end of the 50 MHz centre block, we consider that awarding only the centre 50 MHz in the short term would effectively only allow one new player to enter the market using TDD systems.

3.187 In contrast, we consider that an award of the whole 2.6 GHz band now would enable more than one new player to enter the market. On this basis, we consider that the proposal to release only 50 MHz would not be in the best interests of consumers, in that it would be likely to reduce the competition and innovation benefits that may arise from awarding the whole 2.6 GHz band, and result in:

a) a lower level of competition in the short term than would be the case under an award of all of the 2.6 GHz band because there may be fewer new entrants;

b) a lower level of competition in the longer term (i.e. after the award of the remainder of the 2.6 GHz band) because a window of opportunity for subsequent entry to the market might have closed;

c) a lower level of innovation in the short and in the long term, if a window of opportunity to enter the market closes. Although we would expect that the entry of one player would bring innovation, we consider that the potential for innovation could be higher if more firms were to enter the market;

d) the creation of a situation of artificial scarcity with the result that the cost per MHz of acquisition could be higher if only 50 MHz is awarded as opposed to all of the 2.6 GHz band, particularly if there is a limited window of opportunity for entry;

e) an increased risk of 'hold-up' given the small amount of spectrum to be awarded in the first auction – i.e., a single bidder might bid aggressively in the award of the centre block to drive up auction prices and frustrate the plans of bidders for this block of spectrum.

3.188 Furthermore, awarding all of the 2.6 GHz band at the same time would carry a reduced risk of an inefficient spectrum allocation due to substitution and aggregation risks arising from awarding two parts of the band at different times.

[45] "A comparative analysis of mobile WiMAX deployment alternatives in the access network", May 2007

[46] For example, a network using 10 MHz would require approximately three times the number of base stations than a network using 30 MHz.

[47] The report states that a viable business case may be possible with less than 30 MHz per operator but this could restrict the scope of services or the number subscribers that could be served.

3.189 We do not agree that potential competition from a WiMAX provider using 3.5 GHz is a strong consideration in this context. The main reason for this is that mobile broadband equipment at 3.5 GHz is unlikely to be available on the same timescale as 2.6 GHz and, as we have noted above, there is likely to be a limited window of opportunity for new entrants to make an impact in the provision of mobile broadband data services. In addition, 2.6 GHz has better propagation characteristics than 3.5 GHz which makes it a more attractive band for mobile WiMAX deployment. Furthermore, and as a direct result of the above considerations, the scale of the equipment market for mobile WiMAX devices is likely to be much greater at 2.6 GHz than at 3.5 GHz; this will further enhance the relevance of the new entrants in the 2.6 GHz band as the main source of competition from WiMAX in the provision of mobile broadband data services[48].

The respondent's view that the proposal would reduce uncertainty and increase the efficiency of the award

3.190 The respondent argued that a failure to defer the award of the remaining 140 MHz (or indeed of all the band) would put MNOs at a disadvantage because of informational differences and would lead to an inefficient outcome because:

- the MNOs would be at a disadvantage because of regulatory uncertainties over mobile spectrum liberalisation;
- technical uncertainties, in particular blocking effects from mobile to mobile interference in the top part of the 2.6 GHz band, could have a fundamental impact on the design of the award and should be studied in more detail; and
- there might be greater certainty over demand and over the development of WiMAX and LTE technology in due course.

3.191 Our conclusions on the impact of mobile spectrum liberalisation uncertainty on MNOs' valuations of the 140 MHz which would be delayed in this proposal are the same as our general conclusions on the impact of this uncertainty for the whole band as discussed above. While we agree that there are potential links between 2G spectrum and 2.6 GHz, they are limited and do not appear to be a dominant source of uncertainty given the range of other uncertainties which all bidders (including the MNOs) have to take into account. Our full consideration of these issues is set out above at paragraphs 3.132 to 3.175.

3.192 With regard to blocking effects, we have carried out further research and analysis into these issues. Our assessment, as detailed in section 5, is that the risk of blocking is likely to be low and should not have a material impact on the value of paired use of the band.

3.193 Finally, with regard to uncertainty over demand and the state of technology development, we first consider that markets are capable of dealing with the level of uncertainty which currently exists and that if auction participants bid on the basis of their expectation for demand and technology, the outcome of the auction should be efficient. Moreover, as noted above at paragraph 3.173, the auction has also been designed to assist in price discovery so as to enable bidders to benefit from a reduction in (common value) uncertainties during the bidding process. In addition, there seems no reason to hold up the potential use of WiMAX technology in order to

[48] Although this does not mean that mobile WiMAX technology will not be deployed at 3.5GHz, potentially by existing licence holders who currently provide fixed wireless broadband services.

wait until the LTE standard is clearer. This would likely harm technology competition which we see as being significantly in the interests of consumers.

3.194 We consider that, in general, a very similar set of overall considerations apply to delaying the award of part of the band as to delaying the whole award. Delaying the award could give the MNOs better information over mobile spectrum liberalisation, but it appears unlikely to increase the efficiency of the outcome of the award given that uncertainty over mobile spectrum liberalisation is only one of several uncertainties affecting the valuations of 2.6 GHz spectrum and does not appear to be dominant. There would be some reductions in costs of delay as compared with those set out above because one new entrant could get access to spectrum in the near future. However, the benefits are offset by the disadvantages described above.

3.195 We have considered the proposal, and our analysis, in light of our statutory duties. Whilst awarding some of the spectrum now might partially meet our duties to promote competition and innovation, we do not consider that the effects would be as strong as if we award the entire band now, for the reasons set out above at paragraphs 3.185 to 3.189. It does not therefore seem likely to us that the alternative proposal would create greater benefits for consumers than an award of the whole of the 2010 MHz and 2.6 GHz bands.

3.196 We have further concerns (as set out above) that an award of only a small part of the band, separate from the remainder, may not in fact result in the most efficient award, given our concerns that potential new entry may be limited by this approach and that it may cause artificial spectrum scarcity for some users. This in turn could result in suboptimal use of the spectrum. We do not therefore consider that this proposal would be a more proportionate means of achieving our aims than holding an award for the whole of the band, as it would in fact be likely to fail sufficiently or adequately to meet the aims which an award of the whole band seeks to achieve.

3.197 As a result, we consider that awarding the whole band as soon as possible is likely to generate greater overall benefits for citizens and consumers.

Section 4

Non-technical licence conditions

4.1 This section discusses our conclusions regarding the non-technical licence conditions for the award of the 2.6 GHz and 2010 MHz bands based on feedback on the proposals contained in the December 2006 Consultation and the Discussion Document. Table 1 below summarises our decisions, with the remainder of the section setting out our rationale for reaching these decisions, taking into account in each case relevant comments made in responses to our consultation proposals.

Table 1: Summary of decisions regarding non-technical licence conditions

Area	***Decision***
Technology and service neutrality	The licences for the 2.6 GHz and 2010 MHz bands will contain only those technology and usage restrictions that are the minimum necessary for the efficient management of the radio spectrum, the management of the risk of interference, and compliance with our statutory duties and international obligations. They will not specify either the technology to be used or the services to be offered.
Tradability	The licences for the 2.6 GHz and 2010 MHz bands will be tradable. All types of trade - partial or total; concurrent or outright - will be permitted.
Licence duration / tenure	The licences for the 2.6 GHz and 2010 MHz bands will be of indefinite term with an initial period of 20 years during which time we will not have the power to revoke licences for spectrum management reasons.
Provision of information for possible publication by Ofcom	The licences for the 2.6 GHz and 2010 MHz bands will include a standard requirement to provide us with general information regarding the licensee's equipment and use of frequencies, or the number of base stations in their network, and we may decide to publish some or all of that information from time to time.
Roll-out obligations	The licences for the 2.6 GHz and 2010 MHz bands will not include roll-out obligations.
2012 Olympic Games in London	The licences for the 2.6 GHz and 2010 MHz bands will not include any particular provisions in respect of the London 2012 Olympic Games.

4.2 It is important to note that our decisions concerning the non-technical licence conditions attached to the use of this band are consistent with the Recommendation on the non-technical conditions attached to the rights of use for radio frequencies under the regulatory framework for electronic communications in the context of WAPECS, which was agreed in the European Commission's Communication Committee (COCOM) in March 2008. The UK is required to take the utmost account of this Recommendation.

Legislative background relating to licence conditions

4.3 The Wireless Telegraphy Act 2006 (the "2006 Act") sets out the statutory regime under which we may award licences to use spectrum. Section 9(1) of the 2006 Act provides that a wireless telegraphy licence may be granted subject to such terms, provisions and limitations as Ofcom think fit. As such we have a measure of discretion in deciding what conditions to impose in wireless telegraphy licences, in order to achieve our general statutory duties as set out in Section 3 of this Statement.

4.4 Section 9(7) of the 2006 Act limits that discretion in that it provides that we may only impose terms, provisions or limitations on a licence if we are satisfied that they:

- are objectively justified;
- do not discriminate unduly against particular persons or groups of persons;
- are proportionate to what they are intended to achieve; and
- are transparent in relation to what they are intended to achieve.

4.5 In light of these statutory provisions, we have considered what non-technical licence conditions to include in the licences for the 2.6 GHz and 2010 MHz bands.

Technology and service neutrality

4.6 This part of section 4 explains how we have come to our decision relating to technology and service neutrality of the licences to be awarded for use of the 2.6 GHz and 2010 MHz bands.

4.7 We have considered whether we should exercise our discretion to include technology and usage restrictions in the licences which are the minimum necessary to ensure the efficient management of the radio spectrum, the management of the risk of interference, and compliance with our statutory duties and international obligations. In doing so, we have considered whether the proposed restrictions are objectively justified, not unduly discriminatory, proportionate and transparent.

4.8 In summary, for the reasons set out below and taking into account responses to our consultations, we have decided that the licences will not specify either the technology to be used or the services to be offered (i.e. they will be technology and service neutral).

4.9 This section is structured in the following way:

a) we set out our initial view as to why the licences should be technology and service neutral, as proposed in the December 2006 Consultation and the Discussion Document;

b) we consider the issues raised by stakeholders in response to the December 2006 Consultation and the Discussion Document and set out our assessment of those responses; and

c) we set out conclusions and the reason for our final decision.

In our consultations we proposed that licences for the 2.6 GHz and 2010 MHz bands will contain only the minimum necessary technology and usage restrictions

4.10 We proposed awarding the spectrum on the basis of technology and service neutrality in the December 2006 Consultation and in the Discussion Document. This would also mean that the division of the 2.6 GHz band between paired and unpaired uses would be decided in the auction itself. Moreover this could entail a departure from the CEPT band plan for the 2.6 GHz band which allocated fixed frequency ranges for paired and unpaired uses.

4.11 As noted in the December 2006 Consultation, this is consistent with our preferred approach of imposing the minimum necessary restrictions in existing wireless telegraphy licences (as set out in the SFR Statement,[49] SFR:IP Interim Statement[50] and Spectrum Liberalisation Statement).[51] It would give licence holders more freedom to make efficient use of the spectrum and to deploy the most appropriate services and technologies. It is also consistent with the Framework Directive which requires that national regulatory authorities take the utmost account of the desirability of making regulations technologically neutral. We are required by section 4 of the Communications Act 2003 to meet a number of duties relating to "Community requirements". One of these is a requirement to act in a technology neutral way.

4.12 The SFR:IP Interim Statement also presents the general reasons for our initial proposal to award new licences in a technology neutral fashion under our programme of spectrum awards (see paragraphs 3.53 to 3.67). More specific analysis as it applies to the 2.6 GHz band is detailed in the SFR:IP Interim Statement[52] and in our response[53] to the EC's invitation for comments of June 2005.

4.13 In assessing the impact of allowing bidders to choose their preferred technology and service, we set out our view in the December 2006 Consultation that it would have the following benefits:

i) it would maximise the potential efficiency of the auction as it allows the market to decide the most appropriate use out of the range of services (e.g. mobile broadband, PMSE and potentially mobile TV) and technologies (e.g. UMTS, LTE, WiMAX and DVB) for which the 2.6 GHz band could be used . It would also allow the market to decide on the most appropriate mix of paired and unpaired uses of the spectrum;

ii) it would provide operators with the maximum flexibility to innovate and offer new or improved advanced telephony or broadband wireless services which may not otherwise become available, at least in the near term. This is also in line with our duty to promote innovation;

iii) it would not constrain future use of the spectrum.

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[49] http://www.ofcom.org.uk/consult/condocs/sfrip/sfip/, published in January 2005
[50] http://www.ofcom.org.uk/consult/condocs/sfrip/statement/, published in July 2005
[51] http://www.ofcom.org.uk/consult/condocs/liberalisation, published in January 2005
[52] See in particular paragraphs 4.62 to 4.70 and A.12 to A.38.
[53] 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.

4.14 We also recognised that there could be some disadvantages to a technology and service neutral approach and expanded on these in the Discussion Document. For example, it would expose bidders to some uncertainty over the nature of adjacent use. This uncertainty could affect the relative valuations and utility of the lots. A technology and service neutral approach could also lead to different approaches being adopted across Europe. This could affect operators' ability to take advantage of any benefits from European harmonisation (e.g. the ability to access economies of scale in equipment manufacture).

4.15 However, based on the technical analysis carried out in preparation for and subsequent to the Discussion Document and summarised in Section 5, we do not expect the impact of the uncertainty over adjacent use to be material and expect FDD operators to be able to make use of the same equipment across the UK and Europe.

4.16 In terms of the wider impact on harmonisation, we considered that a technology and service neutral approach is consistent with promoting European harmonisation and still consider this to be the case. Market forces are, in general, better placed than regulators to determine the optimal use of spectrum. If there are substantial benefits from European harmonisation, potential users of the spectrum will have strong incentives to co-ordinate with equipment manufacturers to bring about the level of harmonisation needed to realise these benefits. We consider that the risk of market failure is likely to be small, particularly given that for one of the likely uses of the band - mobile services - the market already comprises multinational service providers and equipment manufacturers.

4.17 Since the publication of the Discussion Document:

a) CEPT regulatory group SE42 has, under mandate from the European Commission, completed its report considering the technical conditions to be applied to the 2.6 GHz band[54];

b) the RSC has, on 2 April 2008, agreed a European Commission decision relating to the 2.6 GHz band which reflects the technology neutral approach agreed in the SE42 report; and

c) the European Communication Committee (COCOM) has agreed a Recommendation on the non-technical conditions attached to the rights of use for radio frequencies under the regulatory framework for electronic communications in the context of the Wireless Access Policy for Electronic Communications (WAPECS). This Recommendation, of which we are required to take the utmost account, recommends that-

   - conditions should be limited to the minimum necessary in order to permit efficient and flexible radio spectrum use;

   - Member States should grant rights of use referred to above for networks capable of providing "Electronic Communications Services" – as defined in the Framework Directive – in general without designating the nature of the service, unless designation of a specific electronic communications service is duly justified and necessary for pursuing general interest objectives in conformity with Community law. Such a designation should not constitute an exclusion of other electronic communications services.

[54] CEPT Report 19 is available at http://www.erodocdb.dk/doks/doccategory.aspx?doccatid=16.

4.18 Further details of this are given in Sections 3 and 6.

Issues raised in responses to the December 2006 Consultation and the Discussion Document

4.19 On the whole, respondents to the December 2006 Consultation agreed with our assessment that technology neutrality would be likely to promote the efficient use of the spectrum.

4.20 However, a small number of responses, primarily four of the five existing MNOs, raised varying concerns with our proposals. These concerns fell into three categories:

a) allowing flexibility in the amount of unpaired spectrum could potentially result in a 2.6 GHz band plan in the UK which differs from the CEPT band plan and could risk the UK becoming misaligned from the rest of Europe, and could impose higher costs and so lead to a worse outcome for UK consumers;

b) the application of technology neutrality in this award was inconsistent with the terms of the existing 3G licences; and

c) there were claims that the existing MNOs had legitimate expectations that the 2.6 GHz spectrum would be reserved only for 3G use and should only be awarded when the existing 3G operators have a demand for the spectrum.

4.21 The majority of responses to the Discussion Document did not comment on our proposals to award the 2.6 GHz and 2010 MHz bands on a technology neutral basis. O2 and another stakeholder did respond and reiterated arguments raised in their responses to the December 2006 Consultation, stating that that they did not agree with the analysis set out in the Discussion Document and that they believed that the application of technology neutrality to the 2.6 GHz award licences was discriminatory with respect to existing 3G licence holders.

4.22 Moreover, responses to the Discussion Document did not put forward any new arguments to rebut our initial conclusions that technology neutrality was unlikely to lead either to a loss of potential harmonisation benefits in this case or to a potential distortion of competition. Moreover, no new arguments have been made to link the issue of whether to make existing 3G licences technology neutral to the 2.6 GHz licensing and award process.

Our assessment of responses to the December 2006 Consultation and the Discussion Document

4.23 Our assessment of the concerns raised in response to the December 2006 Consultation (although the majority of responses were favourable) is covered in detail in paragraphs 8.61 to 8.78 of the Discussion Document. In summary, our view at the time of the Discussion Document was that:

i) adhering to the CEPT band plan carried considerable risk of regulatory failure, particularly given the uncertainty over the most valuable uses of the spectrum, and the limited flexibility under regulated harmonisation to respond to changes in the market;

ii) the application of technology neutrality in the 2.6 GHz award was not likely to distort competition in the provision of mobile services through any potential

inconsistency with the existing 3G licences, and could lead to the introduction of innovative services which could otherwise not be available;

iii) there were no legitimate expectations regarding the reservation of the 2.6 GHz spectrum for 3G use and the award of this spectrum only when the existing 3G operators have a demand for the spectrum (see paragraphs 7.49 to 7.51 of the Discussion Document); and

iv) the conditions of the award of the 2.6 GHz licences (including the national and EU regulatory framework) are different from those of the award of other existing spectrum that may be used for the same or similar services. Therefore we disagreed with the contention that we did not put forward any objective justification for treating the spectrum to be made available in this award differently.

4.24 With regard to O2's response to the Discussion Document which reiterated its view of the potential for discrimination, our assessment is that there is an objective justification for treating the spectrum to be made available in this award differently, and the rationale for this assessment which we set out in the Discussion Document still holds.

4.25 T-Mobile claimed that we had appeared to overlook the point that discrimination is effects based and that our proposals would place existing licence holders at a significant disadvantage by effectively discriminating between or against particular technologies. We do not accept that our analysis in either the December 2006 Consultation or the Discussion Document failed to consider the potential effects of our proposals on existing licence holders in other frequency bands. We also disagree that our proposals discriminate between or against particular technologies, given that our approach will enable the spectrum to be used by a range of technologies, rather than any one specified technology. We therefore remain of the view that a technology and service neutral award of the 2.6 GHz and 2010 MHz bands will not result in discrimination against holders of existing licences.

4.26 We also note that, since the publication of the Discussion Document, proposals on the application of technology and service neutrality to existing 3G licences were set out in Section 16 of our Mobile Spectrum Liberalisation Consultation.[55] In summary, we noted that in general, liberalisation is likely to benefit citizens and consumers. We also noted that our initial consideration suggested that liberalisation of 3G licences for 2.1 GHz spectrum was unlikely to raise significant competition and efficiency concerns. However, since we were unaware of any specific need to bring about liberalisation of 3G licences at the time of that document, we did not make any specific proposals in the Mobile Spectrum Liberalisation Consultation regarding the application of technology and service neutrality to the existing 3G licences. We note that respondents to the Mobile Spectrum Liberalisation Consultation expressed their support for liberalisation of existing 3G licences and some suggested timescales for example, 2008 or as soon as practicable. We are currently considering responses to the Mobile Spectrum Liberalisation Consultation.

4.27 Since the publication of the December 2006 Consultation and the Discussion Document, the RSC has agreed a European Commission decision in relation to the 2.6 GHz band (see Section 3 for further detail). The RSC Decision does not mandate adherence to the CEPT band plan, but rather allows Member States to

[55] "Application of spectrum liberalisation and trading to the mobile sector" http://www.ofcom.org.uk/consult/condocs/liberalisation/, published in September 2007.

designate and award the 2.6 GHz band in any way they choose, subject to certain specified technical parameters to avoid harmful interference. In addition, COCOM has agreed a Recommendation, of which we are required to take the utmost account, which includes a recommendation that supports technology neutrality in the 2.6 GHz and 2010 MHz bands. Our proposals are therefore entirely consistent with the RSC decision and COCOM Recommendation and any decision instead to mandate a specific technology would, in our view, be likely to frustrate a number of our duties including our duty to promote harmonisation.

4.28 It is our view that the benefits and flexibility of a technology and service neutral approach greatly outweigh the potential risks, and are in line with our obligations to promote European harmonisation.

4.29 In contrast, mandating a specific service or technology in the 2.6 GHz and 2010 MHz bands would require us to choose one or more technologies or services, and how much of the band would be allocated to specific technologies or services. We have less information at our disposal than market participants and there is a risk that our choice of technology or services would be sub-optimal. Furthermore, this approach could potentially exclude technologies and services which may provide greater benefits than those chosen.

4.30 In our view, the potential costs of mandating a specific service or technology outweigh any potential benefits (such as providing bidders with certainty over the nature of adjacent spectrum users and giving certainty for international harmonisation of a regulator-determined use).

Conclusion

4.31 Having considered the responses to our consultations, we have concluded that the 2.6 GHz and 2010 MHz licences should be technology and service neutral, as allowing the use of the spectrum to be decided by the market is most likely to promote the efficient use of the spectrum. In other words, these licences should contain the minimum necessary restrictions in order to give licensees flexibility to choose their applications and services. We also consider that the issue of technology neutrality of 3G licences can and should be dealt with separately to the 2.6 GHz auction.

4.32 The licences for the 2.6 GHz and 2010 MHz bands will therefore contain only those technology and usage restrictions that are the minimum necessary for the efficient management of the radio spectrum, the management of the risk of interference, and compliance with our statutory duties and international obligations. They will not specify either the technology to be used or the services to be offered. Technology and usage restrictions will be limited to the minimum technical conditions discussed in Section 6.

4.33 We consider that this approach is objectively justified and proportionate, and provides the most appropriate means of meeting our objectives for the award and our duties under UK and European law. It is not discriminatory, either as to its object or its effect, as it avoids differential treatment of technologies or persons. Finally, we consider that it is transparent in what it seeks to achieve.

Tradability

Summary of our decision

4.34 This part of Section 4 explains how we have come to our decision relating to tradability of the licences to be awarded for use of the 2.6 GHz and 2010 MHz bands.

4.35 We have considered whether we should exercise our discretion to include conditions in the licences to allow licence holders to trade the spectrum which is the subject of their licences. In doing so, we have considered whether the proposed restrictions are objectively justified, not unduly discriminatory, proportionate and transparent.

4.36 In summary, for the reasons set out below, and taking account of responses to our consultations, we have decided that in line with our initial proposals in the December 2006 Consultation and the Discussion Document, the licences for the 2.6 GHz and 2010 MHz bands will be tradable. All types of trade - partial or total[56], concurrent or outright[57] - will be permitted.

4.37 This will provide additional scope for promoting efficient use of the spectrum and responding to changes in markets over time. It will also facilitate use of the spectrum by those who value it most throughout the life of a licence.

Issues raised in responses to the December 2006 Consultation and the Discussion Document

4.38 There was broad agreement among respondents to the December 2006 Consultation that the licences in the spectrum bands should be tradable. However, T-Mobile and O2 argued that the existing 3G licensees would be at a disadvantage to licensees using 2.6 GHz because of differences in tradability.

4.39 The majority of responses to the Discussion Document did not comment directly on our proposals to make the licences tradable. However, O2 and a confidential respondent reiterated the arguments raised in response to the December 2006 Consultation that they believed that making the 2.6 GHz licences tradable would place the existing 3G licence holders at a disadvantage to 2.6 GHz licensees.

Our assessment of responses to the December 2006 Consultation and the Discussion Document

4.40 In the Discussion Document, we noted that the issue of tradability of the existing 3G licences would be discussed in the forthcoming Mobile Spectrum Liberalisation Consultation. We have now published the Mobile Spectrum Liberalisation Consultation and set out our proposals for the application of tradability to existing 3G licences.

4.41 In summary, we are proposing to introduce trading for 3G licences subject to the maintenance of all licence conditions. The specific details will be taken forward in a policy process that is separate to the 2.6 GHz award and there is no reason why they should be linked to this auction. We note that all the MNOs supported the

[56] A total trade is a transfer of all rights and responsibilities associated with a licence, whereas in a partial trade only some of the rights pertaining to, e.g. the geographic area, the frequency range, or the time at which frequencies are used, are transferred.
[57] In a concurrent trade, the recipient gains the rights and responsibilities associated with the licence, but holds them jointly with the original licensee who does not lose those rights and responsibilities.

introduction of trading for the existing 3G licences, as proposed in the Mobile Spectrum Liberalisation Consultation, and that we received no comments opposing this proposal.

4.42 We consider that the holders of existing 3G licences are in a different position from prospective holders of 2.6 GHz licences. We also consider that there is an objective justification for extending trading to 2.6 GHz licences as proposed.

Conclusion

4.43 Having considered the responses to our consultations, we have decided that the licences for the 2.6 GHz and 2010 MHz bands will tradable. All types of trade - partial or total; concurrent or outright - will be permitted.

4.44 We consider that this approach is objectively justified, transparent, and proportionate, and given our proposals to introduce trading in respect of 3G licences, is not discriminatory.

Licence duration/tenure

Summary of our decision

4.45 This part of Section 4 explains how we have come to our decision relating to the duration of the licences to be awarded for use of the 2.6 GHz and 2010 MHz bands.

4.46 We have considered how we should exercise our discretion in relation to the duration of the licences.

4.47 In summary, for the reasons set out below, and taking account of responses to our consultations, we have decided that in line with our initial proposals in the December 2006 Consultation and the Discussion Document is that the licences for the 2.6 GHz and 2010 MHz bands will be of indefinite term with an initial period of 20 years during which time we would not have the power to revoke licences for spectrum management reasons. This would give licensees a reasonable opportunity of recovering their investment.

4.48 Beyond the initial term, the licences can be revoked for spectrum management reasons. We would only consider doing so where there was a need, and only after careful consideration and consultation with the stakeholders affected.

4.49 We also retain the scope to apply administered incentive pricing (AIP) after the initial term of the licence has expired, taking account of circumstances at the time.

Issues raised in responses to the December 2006 Consultation and the Discussion Document

4.50 There was broad agreement among respondents to the December 2006 Consultation to our proposals regarding tenure. However, as was the case with tradability, T-Mobile and O2 argued that differences in tenure between the existing 3G licences and the new 2.6 GHz licences would place the existing MNOs at a disadvantage.

4.51 The majority of responses to the Discussion Document did not comment directly on the conditions of tenure which we proposed. However, in the Discussion Document we suggested that there were a number of options open to us for resolving the future status of existing 3G licences beyond their fixed term (which ends on 31 December

2021). Holding an overlay auction (which would award rights to use the frequencies included in the existing 3G licences beyond 2021) was given as an example of these options.

4.52 In response to this, one MNO claimed that the implications of holding an overlay auction for 3G spectrum would require that the 3G overlay auction was held simultaneously with the 2.6 GHz auction.

Our assessment of responses to the December 2006 Consultation and the Discussion Document

4.53 Our view, as expressed in the Discussion Document, remains that there is likely to be a range of options for resolving future use of the spectrum currently licensed under the existing 3G licences after those licences end on 31 December 2021. We expect to consider those options fully before reaching any decision, and to do so in good time before the licences end, in order to maximise the prospects for an orderly and efficient transition to any new arrangements.

4.54 However, we consider that the resolution of the future of the spectrum held under the existing 3G licences beyond 2021 is a distinct issue from the award of licences now in the 2.6 GHz and 2010 MHz bands. Resolving the first issue is likely to require consideration of a wide range of points that may be relevant at the time, but which cannot sensibly be addressed now, some 13 years before the end of the 3G licences.

Conclusion

4.55 Having considered the responses to our consultations, we have decided that the licences for the 2.6 GHz and 2010 MHz bands will be of indefinite term with an initial period of 20 years during which time we would not have the power to revoke licences for spectrum management reasons. We also retain the scope to apply licence fees such as Administered Incentive Pricing (AIP) to promote efficient use of the spectrum after the initial term of the licence has expired, taking account of the relevant circumstances at the time.

4.56 We consider that this approach is objectively justified, transparent, proportionate, and, in particular in light of the range of options open to us to resolve the future use of the spectrum which is currently subject to the 3G licences, we do not consider that the proposed duration of these licences is unduly discriminatory.

Provision of information to facilitate optimal spectrum use

4.57 In line with our duty to manage the spectrum efficiently, we have decided to include a standard condition in the licences for the 2.6 GHz and 2010 MHz bands to require licensees to provide us on request with general information regarding their equipment and use of frequencies, or the roll-out of their network. From time to time, we may publish aggregated information received on the number of base stations and frequency use in area across the UK, in order to help secure optimal use of the spectrum and facilitate trading, by helping interested parties who do not have access to the 2.6 GHz band to identify areas where they may provide additional services by trading with licensees in that band.

4.58 We consider that this approach is objectively justified to fulfil our statutory duties and objectives, transparent, proportionate and does not discriminate between licensees.

Roll-out obligations

4.59 This part of Section 4 explains how we have come to our decision that the licences awarded in the 2.6 GHz spectrum band will not contain roll-out obligations.

4.60 The statutory framework in the 2006 Act does not impose any obligations on us to include obligations such as roll-out obligations, but gives us a discretion in s.9(1) to impose such terms as we think fit, subject to certain limitations in s.9(7) relating to factors such as undue discrimination, where we do decide to include specific terms in licences. The provisions of s.9(7) which impose these limitations only apply to terms which we decide should be included in licences.

4.61 We have considered whether we should exercise our discretion to include a roll-out obligation in the licences.

4.62 At the time of the auction for the 3G licences in 1999/2000, the Radiocommunications Agency did decide to include roll-out obligations in the 3G licences to ensure efficient use of the spectrum and provide a reasonable level of service to consumers.

4.63 In our SFR:IP Interim Statement of 28 July 2005 we set out our position on the general framework of licence conditions that are appropriate for new licences. In that document, we explained our rationale for proposing not to include roll-out obligations in licences, namely that given that spectrum trading and liberalisation encourage continued efficient use of the spectrum, roll-out obligations are generally unlikely to be necessary to meet our objective of ensuring optimal use of the spectrum. We also explained that we did not consider that there is an automatic linkage between the approach generally proposed for the award of new licences, and the appropriate treatment of licences that have already been auctioned.

4.64 We reiterated this view in our consultations on this award. We also set out the changes in the legal, regulatory and market position since the 3G licences were auctioned, and our view that the overall environment, particularly the EU regulatory framework, has significantly changed since the 3G auction.

4.65 Given the changes since the 3G auction in 2000, and in the absence of a strong policy or regulatory reason, we would not intend to include roll-out obligations in the licences for this award.

4.66 In their responses to our consultations, some of the MNOs argued, amongst other things, that it would be discriminatory for us not to include roll-out obligations in the licences under this award, given the existence of roll-out obligations in the existing 3G licences. We have therefore considered below the specific points raised by respondents to the consultations, which we have taken into consideration before making our decision on this matter.

Structure of this Section

4.67 This section is structured in the following way.

a) We set out our initial view as to why it would not be objectively justified to include roll-out obligations in the licences.

b) We summarise the comments we have received from stakeholders in response to the December 2006 Consultation and the Discussion Document concerning this

issue. We also set out the general objections that were raised against our proposals, namely that they could be unduly discriminatory or distort competition.

c) We set out our consideration of these objections in the light of our own analysis and other responses received from stakeholders. Specifically, we put forward our view that the proposals are not unduly discriminatory and will promote competition rather than distort it.

d) We then examine some further arguments put forward by stakeholders in response to the Discussion Document.

e) Finally we set out our conclusions and the reasons for our decision.

Our initial view was that roll-out obligations at 2.6 GHz are likely to prevent the realisation of benefits for consumers

4.68 Our initial view, as set out in the Discussion Document, at paragraph 8.4, and the December 2006 Consultation, was that there is no objective justification for including roll-out obligations within licences for 2.6 GHz spectrum and 2010 MHz. We considered that if we were to include a roll-out obligation it would be unlikely to generate benefits for consumers and citizens, and might even prevent the realisation of potential benefits from using the spectrum, for the following reasons.

i) We have designed the auction to seek to ensure that the spectrum is awarded to the persons who value it the most. This is the best way to meet our duty to ensure optimal use of the spectrum, and to deliver the greatest value and benefit for consumers[58]. We are obliged to award the spectrum with the minimum of restrictions, and ensure that any restrictions are objectively justified.

ii) Technology and service neutrality are important to promote competition and ensure the efficient allocation and ongoing optimal use of the spectrum. Under a technology and service neutral award we cannot know in advance exactly what services will be provided and how roll-out obligations could be applied to those different services. 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. Imposing roll-out obligations could therefore risk compromising technology neutrality and efficient use of the spectrum.

iii) In order to calibrate roll-out obligations appropriately, it would be necessary to judge the socially optimal level of roll-out. It would also be necessary to ensure that the costs imposed by the obligation were proportionate, and that the mandated level of roll-out was affordable by licensees. Given that the commercial case for many of the likely services will be uncertain and depend on demand, the risk of regulatory failure in setting roll-out obligations is likely to be very high (i.e. roll-out obligations may stifle investment and services that would otherwise be available). Moreover this would run counter to the broad market oriented principles of Ofcom's spectrum management policy.

iv) If there were a social case for achieving particular levels of roll-out, then it is likely that this would better be achieved via subsidies (as have been used on occasion

[58] We believe that private value is likely to be a good proxy for the overall value of the spectrum to society. In our view the additional public value associated with the use of the spectrum is unlikely to vary significantly according to the use of the spectrum.

for fixed broadband[59]) than intervening by attaching conditions to spectrum licences which might distort the allocation of that spectrum. This is consistent with Ofcom's approach in other areas of spectrum management. For example, in considering the use of spectrum for broadcasting services, we have argued that it is likely to be less distorting to intervene with regard to broadcasting output than to intervene in the input market (e.g. subsidising spectrum) in order to take account of broader social value.

v) Roll-out obligations could in this case stifle new entry, and this would conflict with our duty to act in the best interests of consumers by promoting competition. Potential spectrum users could be prevented from using it in the way that would bring the greatest value. This would be particularly likely for new providers of services, who generally face greater risks and uncertainty in establishing their services. Furthermore, it is even more likely where those new providers of services would compete directly with existing established market participants. Those new providers might well therefore be exposed to such issues as increased difficulty in raising capital as a result of roll-out obligations.

vi) In addition, we understand that some existing MNOs might use the 2.6 GHz band to provide extra capacity for 3G services in areas where such additional capacity is required. Roll-out obligations may in effect prevent such a use of the 2.6 GHz band.

vii) If (as we have subsequently decided at paragraphs 4.34 to 4.43), the licences granted under this award would be tradable, roll-out obligations could prevent trades that would otherwise have happened. For example, if a potential buyer wanted to use the spectrum for a different purpose, roll-out obligations may be inappropriate for that use. The additional costs which the potential buyer would face could stop the trade from happening.

Responses to the Consultation Document and Discussion Document

4.69 The responses to the December 2006 Consultation on roll-out obligations fell broadly into two categories. Some responses, such as those of BT and Sprint Nextel, fully supported our proposals on roll-out obligations. Others, in particular most but not all of the existing MNOs, did not support our proposals, making the following points.

a) Four MNOs argued that it would be unduly discriminatory for there to be roll-out obligations in the existing 3G licences but not in the 2.6 GHz licences, and that either roll-out obligations should be removed from 3G licences or that they should be placed on 2.6 GHz licensees.

b) Four MNOs argued that not imposing a roll-out obligation on 2.6 GHz licences would allow new entrants to target the more profitable geographic areas and distort tariffs and competition.

c) O2 argued that if roll-out obligations remained on incumbents, a new entrant without roll-out obligations could obtain the same geographic coverage as the 3G incumbents, but at lower overall cost.

d) O2 argued that disparities in licence conditions could increase an existing 3G MNO's cost of capital and reduce investment and the potential for innovation.

[59] For example, in 2006 the regional development agency, Advantage West Midlands, offered grants for homeowners and communities who could not otherwise get/afford broadband connections.

e) T-Mobile argued that the MNOs have legitimate expectations that licence conditions in the 2.6 GHz licences should match the conditions in the 3G licences.

4.70 There was a similar divergence of views in response to the Discussion Document. Some companies, such as BT and Arqiva, fully agreed with our view that it was not necessary to impose roll-out obligations.

4.71 Others, again principally the existing 3G MNOs except Vodafone, reiterated their views that not to include roll-out obligations for 2.6 GHz while they remain in the 3G licences would be discriminatory and would distort competition. In addition some claimed that we had not put forward any justification in the Discussion Document for different treatment between 2.6 GHz and the 3G licences. Moreover, O2 claimed that the 3G licences should be assessed within the context of the prevailing law, spectrum management policy, market circumstances and technological advances.

4.72 Two MNOs made additional comments on the impact of our proposals on competition.

4.73 To the extent that the responses above raise the issue of whether roll-out obligations remain objectively justified in the existing 3G licences at 2.1 GHz, we do not consider that this is an issue that has to be addressed in our decisions on the 2.6 GHz award. If it were to become apparent that the continuation of the roll-out obligations in the 3G licences was having an adverse effect on the provision of services to consumers or on the optimal use of spectrum, or otherwise had ceased to be objectively justified, then we have the powers to consider and, if appropriate, remove the conditions at that time.

4.74 We have considered the consultation responses which we received on this issue and have taken them into account in making our decision on whether or not to include a roll-out obligation in the licences under this award.

We do not agree that our proposals are discriminatory

4.75 We note that as a public authority, we are under a general duty not to discriminate without objective justification. It is settled case law that discrimination may 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.

4.76 We are also under a specific obligation only to impose licence terms, provisions or limitations in wireless telegraphy licences which are not unduly discriminatory[60]. However, we have been proposing not to include a licence condition imposing roll-out obligations, and the specific provisions of s.9(7) of the 2006 Act do not apply to a consideration not to include provisions in licences.

4.77 At a general level, and as set out in the December 2006 Consultation and the Discussion Document, we consider that past decisions on licensing conditions do not necessarily determine how future licensing decisions should be made, subject to relevant consideration of the requirements of EU and UK law.

4.78 In the Discussion Document, we considered that the changes in the legal, regulatory (both UK and EU) and market position since the 3G licences were auctioned indicate

[60] See s.9(7)(b), Wireless Telegraphy Act 2006.

that the overall environment has significantly changed on a number of levels since the 3G auction. In particular, the EU regulatory framework that was put in place in 2002 means that we must make spectrum available with the minimum restrictions necessary unless there are objectively justified reasons to the contrary. There is also a general move at EU level to a more technology neutral framework for issuing spectrum[61]. It remains our view that the environment has changed for these and other reasons since the 2000 auction.

4.79 In addition, the 3G spectrum currently licensed to MNOs has been available for mobile use since 2000 while the 2.6 GHz band is only becoming available in the UK for such uses now. The market has developed considerably in that intervening period. As a result, the current spectrum award will not take place under similar market conditions to those which prevailed at the time of the 3G auction. Furthermore, the 2.6 GHz band offers significant scope for innovation, which may differentiate service providers using this band from the 3G licensees using the 2.1 GHz band. Another area of differentiation is that incumbents holding 3G licences at 2.1 GHz may also have significant first mover advantages over new entrants. Even if this were not the case, bidders at the time of the 3G auction in 2000 were fully aware of the roll-out obligation and the possibility of future spectrum awards, with different conditions, that might allow market entry. Hence, 3G licensees would have taken the impact of the roll-out obligations into account in their auction bids and should not now be disadvantaged with respect to potential new entrants without roll-out obligations.

4.80 In the Discussion Document, we also considered that the existence of conditions in existing licences (for the use of different spectrum) that vary from those proposed for new licences at 2.6 GHz is not a justification for preventing the introduction of measures when these new measures are likely to bring benefits to consumers and to improve the efficiency with which spectrum is used (for example by allowing spectrum trading). We consider that this remains the case.

4.81 For the reasons set out above, we remain of the view that the conditions that are relevant to the award of the 2.6 GHz licences are different from those that were relevant to the award of other licences, notably the 2.1 GHz licences. We therefore disagree with O2's contention, that we have not put forward any objective justification for treating the spectrum to be made available in this award differently. We also disagree with O2's comment in the same response that in order to justify objectively our decision with respect to roll-out obligations and 2.6 GHz licences, we need to re-assess the licence conditions for the existing 3G licences. We do not consider that concerns relating to whether conditions in other licences are objectively justified are relevant to our decision on the conditions that should be set for the 2.6 GHz licences.

4.82 In conclusion we consider that our proposals are objectively justified, and do not discriminate unduly against existing licensees.

We consider that our proposals will promote competition rather than distort it, as argued by some respondents

4.83 As noted above, a number of respondents to the Discussion Document claimed or reiterated their earlier views that a failure to impose a roll-out obligation on licensees at 2.6 GHz, while 3G licensees remain subject to roll-out obligations, could lead to a

[61] For example, the EU's WAPECS (Wireless Access Policy for Electronic Communications Services) programme aims to promote more flexible use of spectrum by removing unnecessary restrictions. This is reflected in the COCOM Recommendation agreed in March 2008 of which we are required to take the utmost account.

distortion of competition. In particular some existing MNO respondents claimed that if 2.6 GHz licensees provide mobile services on a geographically limited basis, this could distort competition between incumbents and new entrants, distort retail tariffs, and potentially have a negative impact on investment by incumbents. In so far as these arguments are different from the respondents' claims that our proposals are discriminatory, they are considered below.

4.84 This sub-section sets out our view that including a roll-out obligation would promote competition rather than distort it and is therefore consistent with one of our primary duties which is to promote competition. The award of 2.6 GHz spectrum will create the opportunity for new entrants to provide mobile services, including mobile broadband or data services. As a result of new entry, the level of competition would be expected to increase[62].

4.85 Our proposals also satisfy another of our duties, to have regard to promoting innovation, because new entrants may enter using new technologies which are likely to allow new services to be offered.

4.86 Although, as one MNO has pointed out, there are other routes to starting the provision of mobile services, for example liberalisation of existing spectrum to enable the provision of mobile services (as recently granted to UK Broadband for its 3.4 GHz licence[63]), or future spectrum awards, 2.6 GHz represents a major opportunity for new providers of mobile services to emerge.

4.87 Moreover, by promoting innovation, consumers may benefit not only from new technology and services, but also enhanced competition in the longer term, since providers may compete over different platforms.

Distortion of competition

4.88 As noted above, some respondents have suggested that geographically limited entry (sometimes known as cherry picking) could happen as a result of our proposals and would distort competition. We do not consider that geographically limited entry, were it to happen, would be likely to distort competition unless:

a) incumbents have incurred material costs as a result of the roll-out obligation which they were not able to take into account when bidding for the 3G licences in 2000; **and**

b) one or more of the following conditions holds-

- one or more incumbents is likely to exit the market as a result of a difference in applying roll-out obligations to 2.6 GHz as opposed to 3G licences;

- incumbents are unable to respond to tariffs introduced by new entrants whilst maintaining output and investment because of the roll-out obligation in their 3G licence;

[62] Without conducting a full market review, it is difficult to quantify precisely the potential impact on competition. However, we do not consider that it is necessary to conduct a full market review in order to identify that there is scope for competition to be promoted. Moreover, mobile broadband services are in their early stages of development, making a review difficult to carry out.
[63] See the statement published in November 2007, available at http://www.ofcom.org.uk/consult/condocs/bb_application/statement/.

- inefficient entrants are encouraged to enter directly as a result of not including roll-out obligations in 2.6 GHz licence.

4.89 **Alleged additional cost burden of existing obligations.** While we consider that not imposing a roll-out obligation on 2.6 GHz licensees would not give them an unfair advantage, some incumbent MNOs have argued that the roll-out obligations in the 3G licences do impose additional costs on them and that our policy would not allow them to recover these costs.

4.90 We consider that it is reasonable to expect that bidders in the 3G auction in 2000 would have taken the cost of meeting the roll-out obligations, and any other impact on the profits they could generate from the exploitation of the spectrum, into account in the bids they made. 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 and details of the roll-out obligation were clearly set out in the Information Memorandum to the 3G award[64]. Moreover, at the time of the 3G auction in 2000, the participants were made aware that additional spectrum suitable for providing similar services could be made available in the future, and no guarantee was given that different spectrum becoming available later would be subject to the same conditions as in the 3G licences[65]. In other words, to the extent that roll-out obligations were expected to impose a cost burden, the existing MNOs had the information and opportunity to internalise this factor by bidding a lower price for the 2.1 GHz licences that would otherwise have been the case and any cost burden should have already been discounted in the original price paid to acquire the licence.

4.91 We note that some MNOs have published figures for their network coverage which exceed the requirement set out in the roll-out obligation which suggests that the obligation has not been a burden for them[66] and that T-Mobile and H3G have announced their intention (subject to regulatory requirements) to jointly extend their coverage further.[67] We also note that no respondent has presented evidence to indicate that the roll-out obligation has imposed a material cost on them, over and above that which they would have incurred if there had been no roll-out obligation, and which they had been unable to take into account in the 3G auction[68].

4.92 For these reasons, we do not consider that the first of the necessary conditions (for geographically limited entry to distort competition) set out in paragraph 4.88 above applies. For the sake of completeness, however, we consider below the other three

[64] In section 2.2 (in particular paragraph 2.2.4) and at appendix K of the Information Memorandum: 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".

[65] See the Information Memorandum for the 3G auction, available at http://www.ofcom.org.uk/static/archive/spectrumauctions/Information%20Memorandum/index.htm, in particular section 3.4.1 and A5.2.

[66] e.g. H3G claimed 88% 3G population coverage in May 2006 http://www.three.co.uk/news/h3gnews/pressnewsview.omp?collcid=1019745742912&cid=1147184210927&i. Orange claimed over 90% outdoor 3G population coverage in February 2007, http://pressoffice.orange.co.uk/Content/Detail.asp?ReleaseID=651&NewsAreaID=2.

[67] See for example http://www.hutchison-whampoa.com/upload_docs/2007/12/Telco/1975/1975_eng.htm.

[68] We are aware that, similarly, 2.6GHz licensees would be able to take account of any roll-out obligations placed on them that were announced before the award. However, we have set out above at paragraph 4.68 above our reasons for not imposing such obligations within licenses for 2.6GHz and 2010 MHz spectrum.

conditions set out in paragraph 4.88, one of which would also need to apply in order for geographically limited entry to run the risk of distorting competition.

4.93 **Likelihood of market exit.** We consider that it is unlikely that incumbent 3G service providers would exit the market if no roll-out obligations were included in the 2.6 GHz licences. Assuming that the incumbents were efficient, we should only be concerned if the "business stealing effect"[69] of entry (with respect to entrants not having roll-out obligations) on the incumbents' profits was sufficiently large that incumbents were unable to cover their costs (including fixed costs) in the long run. However, we do not consider that this is likely to happen. Firstly we note that the potential to provide innovative new services with this spectrum is high, therefore the likelihood of entrants directly cannibalising incumbents' services is reduced.

4.94 Furthermore, existing MNOs have some eight years' advantage in establishing their brand and customer base for 3G services as well as potential economies of scale over new entrants. We note the comment made by some MNOs that this could be undermined by giving new entrants unfair advantages through regulation. However, as discussed in paragraph 4.68 above, we consider that there is no objective justification for imposing roll-out obligations on the 2.6 GHz licences, and given our view that incumbents should have taken into account the costs of meeting the roll-out obligation when determining their 3G licence bids, we do not consider that new entrants would receive an unfair advantage through regulation if no roll-out obligations are included in the licences under this award.

4.95 Coverage may also be a major advantage for incumbents. Coverage confers a competitive advantage to the extent that users value the ability to use mobile broadband services more widely. We note that in its response to the Mobile Liberalisation Consultation, one MNO referred to the experience in Japan in the provision of 3G/advanced data services, where adoption by consumers only started taking off significantly when population coverage reached levels of the order of 90%.

4.96 Moreover, although roaming may allow the reach of geographically limited networks to be extended, it is not an ideal substitute. Roaming may not be available or a viable option (a) if it is not offered, or (b) if the new licensee uses a technology that is different from that used by the incumbent 3G MNOs. If roaming were available, an entrant using roaming services would inevitably trade off potential reductions in cost against the loss of control of network roll-out and service functionality, since 3G networks are still being rolled out and developed. We consider it unlikely, therefore, that on the lack of a roll-out obligation would lead to the exit of one of the incumbents in the market, even if an incumbent MNO did enter into a roaming agreement with a new entrant. We also note that no incumbent MNO presented evidence to show that exit would be likely because of a difference in roll-out obligations as between the 2.6 GHz licences and the existing 3G licences.

4.97 **Ability of incumbents to respond to entry**. In the December 2006 Consultation, we suggested that incumbent MNOs do have flexibility to respond to entry by targeting tariff changes on particular services or segments of the market that might fit closely with areas which are more profitable and that might be targeted by new entrants.

4.98 Some MNOs suggested that operators might have to de-average tariffs on a geographic basis to respond to entry. They argued that this could have significant adverse implications for consumers. We note that there is nothing to prevent MNOs

[69] The extent to which entrants take market share from incumbents by providing the same services.

from de-averaging their tariffs on a geographic basis, and it is a matter for them, and not Ofcom, to decide how they choose to set their retail tariffs.

4.99 Moreover, we believe that the MNOs have some choice in how they might change tariffs in response to entry. In the December 2006 Consultation we set out ways in which incumbents could respond to geographically focused entrants without geographic de-averaging of tariffs. For example, MNOs could target customer segments such as corporate and high volume users with special packages or volume discounts. We consider, therefore, that incumbents would not necessarily need to de-average tariffs on a geographic basis.

4.100 Additionally, it is not clear that a new entrant would be able to offer geographically targeted services at lower costs because of the value that consumers attach to coverage. The properties of 2.6 GHz spectrum mean that more sites are required to achieve a similar level of coverage than is the case for lower frequency spectrum. Even if new entrants did offer geographically targeted services, this might be due to their use of an intrinsically more advanced or efficient technology which would be efficient and desirable.

4.101 We also note that no respondents offered evidence to support claims that tariff structures would be distorted in an inefficient sense, as opposed to tariff structures being changed in response to competitors' activities. Equally, no respondents provided supporting evidence to show that services to customers not targeted by new entrants would be restricted as a result.

4.102 **Risk of inefficient entrants.** We do not consider that inefficient entry, in the sense of entry by competitors who in the long run have substantially higher unit costs, is likely to be sustainable. Although in the short run, efficient entrants may have higher unit costs than incumbents due to operating at a lower scale than incumbents, it is the long run which matters for the viability of entry. Furthermore, the spectrum will be auctioned so that it is awarded to the bidders who value it the most, and we would expect 2.6 GHz licensees to be subject to normal competitive pressures once they start providing services. Hence, we would not expect bidders to acquire the spectrum if there was a high risk that entry would not be sustainable. Moreover, we have received no evidence to suggest that new entry, in general, would be likely to be inefficient as a result of not imposing roll-out obligations (notwithstanding O2's arguments on new entrants supplementing geographically limited network roll-out with roaming services, a point which is discussed below).

4.103 In summary, we do not consider that the conditions set out at the start of this subsection at paragraph 4.88 are likely to hold. Therefore we do not consider that our proposal not to impose roll-out obligations in 2.6 GHz licences would be likely to distort competition. However, in their responses to the Discussion Document, two MNOs, a confidential respondent and O2, raised concerns on distortion of competition in a different framework to the one we set out above. Each raised some new arguments for how competition could be distorted by our proposals. Therefore, although we consider that our arguments set out above demonstrate that our proposals would be likely to promote competition rather than distort it, we assess these additional issues in the following sections.

Additional arguments put forward on the potential for distortion of competition

4.104 This section considers the additional arguments put forward by O2 and a confidential respondent concerning:

i) whether issues of unfair competition could arise from not imposing roll-out obligations on 2.6 GHz licensees; and

ii) whether new entrants who purchased roaming services from incumbents would be able to undercut the incumbents given the prices that incumbents would charge for roaming.

No issue of unfair competition arises from not imposing roll-out obligations on 2.6 GHz licensees

4.105 One MNO proposed that there was a case for imposing roll-out obligations on grounds of "fair competition". However, it proposed distinguishing national providers (to whom the obligations should be applied) from niche providers (to whom they should not). They considered that the obligation would only be triggered if service providers met the following criteria:

- the provider advertised a national service; or
- the provider's coverage exceeded 50% of the UK population.

4.106 As discussed earlier, we concur with the MNO's view that that the entry of niche providers which do not offer a national service should not be considered as providing unfair competition. However, for the reasons set out at paragraphs 4.88 to 4.103 we also consider that non-niche entrants would not have an unfair competitive advantage vis-à-vis incumbent MNOs.

4.107 We consider that linking licence obligations to the manner in which a provider advertises its service is flawed, in that it would be relatively straightforward for that provider to avoid such a measure. Equally, such a licence condition would depend to a significant degree on the definition of what constituted a "national" service for these purposes, which may in itself be open to considerable differences of opinion. To the extent that such an obligation was an oblique attempt at regulating a provider's advertising itself, we do not consider that this is an issue that should be addressed through regulatory conditions in spectrum licences.

4.108 Moreover, save for similar advertising considerations as set out above, we do not see any cause for concern if an entrant's coverage reaches 50%, and we do not consider that imposing a roll-out obligation in the case where a new entrant's coverage exceeds 50% would be likely to bring benefits for consumers. It could also act as a disincentive to entrants to extend coverage to 50% for fear of being required to roll out beyond the level they deemed to be commercially justified. This could therefore prevent some consumers from being able to receive services that they would otherwise be able to receive.

New entrants receiving roaming services from incumbents would not be able viably to undercut them

4.109 O2 made a number of arguments as to how competition might be distorted if roll-out obligations are not included in 2.6 GHz licences while they are contained in the existing 3G licences. These arguments do not take into account the fact that rational bidders for the 3G licences would have factored the costs of meeting the roll-out obligation into their bids for the spectrum. Moreover, it is not clear that the incumbent MNOs have suffered a burden because of the obligation since some of them appear to have gone beyond the required level of coverage. However, we address below the specific points which O2 raised.

4.110 O2 argued that competition would be distorted not only because new entrants could enter on a geographically limited basis but also because competition at the wholesale level would force incumbents to provide roaming at incremental cost in those areas where entrants did not build network. Hence, entrants would be able to set prices below the level that incumbents needed to set prices in order to earn a profit and recover their fixed costs.

4.111 In its response to the Discussion Document, O2 provided further arguments to support its claim that an entrant which targeted urban areas and on which a roll-out obligation had not been imposed, would be able to purchase roaming services (outside the urban areas it targets) at incremental cost.

4.112 In the Discussion Document, at paragraphs 8.34 to 8.45, we put forward a number of arguments explaining why we consider that the model of competition put forward by O2 might not apply and why other models could be applied which would lead to an outcome where entrants were not provided roaming at incremental cost. O2 in its response accepted that our characterisation of the market could be right in theory, but argued that the actual nature of the potential 3G roaming services and competition in their supply means that its economic model was more likely to fit the reality than those which we put forward. However, we are not convinced by O2's arguments.

4.113 For example, O2 disputed our contention that roaming services are likely to be differentiated. In the Discussion Document, we argued that if roaming services were differentiated, it was possible that roaming services might not be provided at all, or that if they were, it was likely that they would be priced above incremental cost. O2 accepted that if roaming services were differentiated, its argument that roaming services would be provided at incremental cost might not hold. The key consideration is the extent to which differences would affect consumers' choice of service provider. O2 argued that because MNOs have to meet the roll-out obligation they will all have at least 80% coverage. This will limit the extent to which 3G roaming services would be differentiated in practice. Therefore, O2 argued, roaming is likely to be provided at incremental cost as set out in their response to the December 2006 Consultation.

4.114 We agree that a key consideration is whether the level of differentiation is sufficient to affect consumers' choices of service provider. While it could be the case that differences in the extent of coverage are not significant, we consider that there is greater potential for differences in the "depth" of 3G network coverage. This will constrain the quality, scope and volume of services that can be provided in any particular area, and so could be an important differentiator of the 3G services that a roaming operator could provide.

4.115 As yet 3G networks are not fully mature and may be subject to significant differences in how the depth of 3G coverage develops; moreover there are considerable uncertainties and differences of view over how fast mobile broadband services could develop, as acknowledged by respondents to our Mobile Liberalisation Consultation. As a result, MNOs could follow significantly different strategies for increasing the depth of 3G coverage. If this were the case, there would be some differentiation in the 3G roaming services that they could offer, at least in the short to medium term. In the longer term their strategies could converge, particularly once demand was more certain. We also note that we received confidential correspondence from a stakeholder in a different context which reported one MNO's claims that it had superior network coverage, reliability and quality to its competitors.

4.116 O2 suggested that where there are differences in 3G network coverage, fill-in services could be provided, presumably using 2G networks. If this is the case, then while this may indeed be adequate for voice and basic data services, we consider it unlikely that 2G fill-in services would be an adequate replacement for the mobile broadband services which we consider new entrants are likely to offer.

4.117 As for whether competition in mobile could be modelled as a two-stage process in which operators fix capacity then compete on prices (which would lead to roaming charges being set above incremental cost levels), O2 argued that capacity in mobile networks is not fixed. We agree that the capacity of mobile networks is not fixed, particularly in the long term, but we consider that it is difficult to roll out significant changes in capacity across a mobile network in the short term (while not damaging service quality), particularly if an operator is already using all of its spectrum.

4.118 For the reasons given earlier, the incumbent MNOs should have taken the costs of meeting the 3G roll-out obligation into account when bidding for their spectrum and, as a result, we do not consider the additional arguments put forward by O2 have a material bearing on the question of distortions in competition. However, even if this were not the case, we are not convinced by the arguments put forward to show that entrants would be able to undercut incumbents. In particular, the prospect that 3G networks may be differentiated in terms of depth of coverage and range of services makes this less likely to be true.

4.119 We also note that O2 made a number of further specific points on this issue that relate to confidential information which we are unable to address publicly in this Statement. These points are therefore addressed in Annex 5 the contents of which have been redacted from the published version of this Statement. In summary, none of these further points raised by O2 affects or changes in any way the conclusions and decisions which we have reached in this Statement.

External pairing of 2.6 GHz spectrum

4.120 O2 also raised in its response to the Discussion Document the concern that there could be problems in external pairings of 2.6 GHz with 3G TDD spectrum at 1900-1920 MHz. It suggested that it could be problematic if one part of the pairing is subject to a roll-out obligation and the other is not.

4.121 We consider that problems of this nature are unlikely to arise if 3G TDD spectrum is paired with TDD spectrum in the 2.6 GHz band. The roll-out obligation applies to the licences held by the existing 3G licensees, not to specific frequencies held under that licence (i.e. the roll-out obligation is not linked expressly to either the FDD spectrum, which forms the majority of the allocations and is currently in use, or the TDD spectrum, which might be used for external pairing). It is for 3G operators to decide how they meet the obligation using the spectrum held under the existing 3G licences, and this can be achieved without using the spectrum that could be paired externally.

4.122 We also explained in paragraphs 5.33 to 5.53 of the Discussion Document why we considered it very unlikely that external pairing of the 2.6 GHz spectrum with 1900-1920 MHz spectrum would be amongst the more valuable uses of the 2.6 GHz spectrum. O2 did not argue against this conclusion in its response to the Discussion Document.

No legitimate expectations arise in relation to roll-out obligations

4.123 T-Mobile stated in its response to the December 2006 Consultation that it considered that the MNOs have legitimate expectations that licence conditions in the current licences should match those in the 3G licences.

4.124 We note that legitimate expectations in law, such as those claimed in this regard, may arise where a public authority's conduct or statements clearly and unequivocally support a party's interpretation of the promises, undertakings or representations made by the public authority.

4.125 We have considered the statements and representations made at the time of the 3G auction and since that auction. We do not consider that statements or representations have been made which would give rise to a legitimate expectation in law that any future licence conditions would match those in the existing 3G licences, such that we would now be prevented on the basis of the principle of legal certainty from imposing different conditions on new licences. We note that no respondents have provided any evidence of statements or representations made which support the view that legitimate expectations in law have arisen in this regard.

4.126 As we set out in our Discussion Document, spectrum licensees are not entitled to expect that spectrum management regulation and policy will remain static, and this remains our position now.

Conclusion

4.127 In conclusion, we do not consider that there is a strong policy or regulatory reason to include a roll-out obligation in the licences under this award. We do not consider that setting roll-out obligations would generate additional benefits for consumers. If we did include roll-out obligations in these licences, the effect could be to restrict entry, which might limit the competition and innovation that would otherwise be derived, to the detriment of consumers.

4.128 We have considered the responses made to our consultations and in particular the arguments made by a number of the MNOs that we should include a roll-out obligation, because not to do so would be discriminatory, and would distort competition.

4.129 For the reasons set out above in this section, we do not agree that it would be discriminatory not to include roll-out obligations in the licences under this award even though roll-out obligations were imposed on the 3G licences auctioned in 2000. The 2.6 GHz spectrum is different to the 3G spectrum awarded in 2000, and the changes in spectrum management policy, the market and technology are such that the conditions of the award are materially different. Bidders in the 3G auction in 2000 were made fully aware of the roll-out obligations at the time and should have taken into account any additional costs that the obligations would have imposed on them. Moreover, whether the conditions in other licences are objectively justified is not a matter that should necessarily determine what conditions are imposed on the use of 2.6 GHz spectrum.

4.130 We also do not agree that a decision not to include a roll-out obligation would distort competition. We consider that not including a roll-out obligation is likely to promote competition by encouraging entry into the market on an efficient basis. At the time of the 3G award in 2000 it was made clear to the participants that other spectrum suitable for 3G services might be made available in the future, and no statement was

made at the time that such spectrum would be subject to roll-out obligations[70]. We do not consider it likely that inefficient new entrants will enter the market in a sustainable manner, and incumbents will have first-mover advantages and may have lower unit operating costs. Incumbents should be able to respond to entry in a variety of ways, including by changing their tariff packages if necessary.

4.131 We have therefore decided that roll-out obligations will not be included in 2.6 GHz licences.

2012 Olympic Games

Summary of our decision

4.132 This part of Section 4 explains how we have come to our decision relating to the 2012 Olympic Games in the context of this award. We have considered whether we should exercise our discretion to include conditions in the licences under this award relating to the 2012 Olympic Games.

4.133 In summary, for the reasons set out below and taking account of responses to our consultations, we have decided that the licences for the 2.6 GHz and 2010 MHz bands will not include any particular provisions in respect of the London 2012 Olympic Games.

Our consultation proposals

4.134 The December 2006 Consultation did not contain any specific considerations regarding the 2012 Olympic Games. However, paragraphs 6.60–6.71 of the Discussion Document explained our initial proposal that the licences for the 2.6 GHz and 2010 MHz bands would not include a provision for us to vary the licence terms for the purpose of meeting the UK's international obligations relating to the Games.

4.135 The Discussion Document noted that Section 5 of the Communications Act provides that the Secretary of State may direct Ofcom in relation to our functions relating to the management of the radio spectrum. It also noted that the Secretary of State's powers extended to issuing directions to us for the purpose of securing compliance with international obligations of the United Kingdom. The Government advised us that the guarantees given to the International Olympic Committee (IOC) constitute international obligations of the United Kingdom.

4.136 It is not possible for the Secretary of State to fetter his discretion about the exercise of his power to issue directions to us relating to the management of the radio spectrum. However, neither the Government nor Ofcom presently expect to exercise their powers to vary or revoke the licences to be awarded under the proposed award process, without the consent of the licensees, for the purpose of meeting obligations relating to the 2012 Olympic Games.

Issues raised in responses to the Discussion Document

4.137 A small number of responses to the Discussion Document considered the potential inclusion of a condition in the licences with respect to the 2012 Olympic Games. BT

[70] See the Information Memorandum for the award published in November 1999, available at http://www.ofcom.org.uk/static/archive/spectrumauctions/Information%20Memorandum/index.htm.

stated that they viewed the inclusion of a condition as neither necessary nor desirable.

4.138 Arqiva commented that they recognised that this was an issue for consideration by the Government rather than Ofcom but felt that any clarity that we could provide on the process that we would be likely to adopt in the eventuality of spectrum being required to be surrendered would be appreciated.

4.139 The Spectrum for Programme Makers Forum commented that it was not clear why we were not looking to include a specific licence condition to require licence holders to make spectrum available.

Our assessment of responses to the Discussion Document

4.140 With regards to Arqiva's comment, we do not feel it is appropriate to speculate on the process we would expect to follow as further details of the likely spectrum requirements, such as the total amount of bandwidth and duration of assignment, need to be understood in advance. Nonetheless, any requirement to release spectrum for the period around the 2012 Olympic Games would be communicated to the relevant parties in adequate time for discussions to be carried out and preparations made.

4.141 With regard to the Spectrum for Programme Makers Forum comment, our response is that it is within the Secretary of State's power to issue directions to us to secure compliance with international obligations of the United Kingdom, and the guarantees given to the IOC constitute such an international obligation[71]. Neither the Government nor Ofcom expect that it will be necessary to exercise their powers to vary or revoke the licences to be awarded under the proposed award process, without the consent of the licensees, for the purpose of meeting obligations relating to the 2012 Olympic Games. However, the lack of a specific condition in the licences for the 2.6 GHz band relating to the 2012 Olympic Games does not restrict the Secretary of State's or Ofcom's ability to exercise these powers if required.

Conclusion

4.142 Having considered the responses to our consultations, we have decided that the licences for the 2.6 GHz and 2010 MHz bands will not include any particular provisions in respect of the London 2012 Olympic Games.

[71] As detailed in paragraphs 6.60–6.71 of the Discussion Document, and also in Section 5 of the Information Memorandum for this award published alongside this Statement.

Section 5

Interference conditions and spectrum packaging

Introduction and summary of decisions

5.1 In this section we provide our final assessment of the interference issues that arise from the use of the 2.6 GHz and 2010 MHz bands and we explain the basis for our decisions in relation to spectrum packaging that result from this. We cover:

- in-band coexistence of different uses at 2.6 GHz, covering in particular base-to-base and terminal-to-terminal[72] interference between paired and unpaired users, both of which have been subjects of significant comment from stakeholders;
- the implications of allowing flexibility for award outcomes at 2.6 GHz that might differ from the CEPT band-plan contained in ECC Decision (05)05;
- potential interference to and from adjacent users to the 2.6 GHz band in the UK, such as PMSE, aeronautical radar use above 2700 MHz, and other services;
- potential interference to and from adjacent users to the 2010 MHz band in the UK, such as PMSE, mobile and space operations, and other services; and
- the potential impact of international uses of the 2.6 GHz and 2010 MHz bands and coordination with neighbouring countries.

5.2 Table 2 below summarises the decisions we have taken on spectrum packaging for the 2.6 GHz band as a result of the analysis of interference conditions. The 2010 MHz band will be packaged as a single lot.

Table 2: Summary of spectrum packaging decisions for 2.6 GHz band

Area	***Decision***
Categories of lots	There will be two categories of lots in the 2.6 GHz band: paired lots (two blocks of 5 MHz each separated by 120 MHz) and unpaired lots (one block of 5 MHz).
FDD / TDD adjacencies	Paired (FDD) and unpaired (TDD) users will be separated by a 5 MHz block in which base station transmission powers will be restricted. This will be achieved by placing restrictions on in-band power within the lowest 5 MHz block (restricted unpaired block) in each range of contiguous blocks assigned to a user of unpaired lots. Other blocks corresponding to unpaired lots will be standard unpaired blocks. Block #24 at 2615-2620 MHz will also be a restricted block so long as block #25 is assigned for paired use.

[72] Referred to as mobile-to-mobile interference in the Discussion Document

Use of generic lots	The technical conditions derived from CEPT Report 19[73], and the nature of the interference environment with adjacent users, are such that there should not be significantly different utility or costs of deployment associated with lots at different frequencies. This implies that the interference and coexistence environment is consistent with the use of generic blocks in each category of 2.6 GHz lots.
Flexibility of band-plan	We will not impose a set band-plan as part of the award, with pre-determined amounts of paired spectrum and unpaired spectrum. Instead, we will allow the market to determine through the auction how much spectrum there will be assigned in each of the two categories at 2.6 GHz.

5.3 The first four parts of Section 5 below address in-band interference issues and cover:

- the main features of spectrum packaging for the 2.6 GHz band, together with a summary of the major issues raised in consultation responses;
- an overview of in-band coexistence of different uses within the 2.6 GHz band;
- an updated assessment of base station to base station interference within the 2.6 GHz band, together with a review of more detailed issues raised on this subject in consultation responses and our conclusions on the implications for technical conditions and utility of blocks adjacent to FDD / TDD boundaries;
- an updated assessment of terminal-to-terminal interference within the 2.6 GHz band, together with a review of more detailed issues raised on this subject in consultation responses and our conclusions on the implications of paired / unpaired flexibility resulting in a departure from the CEPT band-plan.

5.4 The next two parts of Section 5 consider neighbouring users to the 2.6 GHz band covering:

- coexistence with UK uses in spectrum adjacent to the 2.6 GHz band;
- international implications of 2.6 GHz use.

5.5 The following part of Section 5 draws together aspects of the analysis referred to above (on in-band interference and neighbouring users) to assess the implications of the overall interference environment for the utility of different frequencies within the 2.6 GHz band;

5.6 The penultimate part of Section 5 turns to the 2010 MHz band and addresses issues relating to coexistence with uses in spectrum adjacent to the 2010 MHz band.

5.7 The last part of this Section gives a summary of the main conclusions.

[73] "Report from CEPT to the European Commission in response to the Mandate to develop least restrictive technical conditions for frequency bands addressed in the context of WAPECS," CEPT Report 19, December 2007.

Main features of the spectrum packaging for the 2.6 GHz band

5.8 The main features of the spectrum packaging for the 2.6 GHz band that we have proposed in our consultations were as follows.

Components

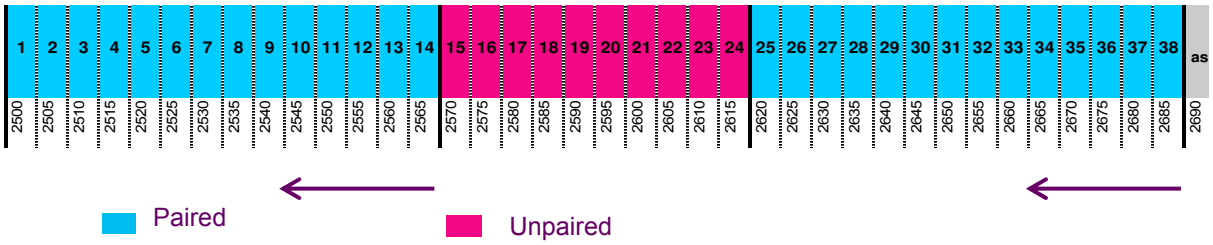
- Spectrum should be made available in the form of 5 MHz individual unpaired (TDD) lots or in the form of 2x5 MHz paired (FDD) lots, each of which can be aggregated to form larger channel widths.

- The paired lots should be split into uplink and downlink frequencies separated by a 120 MHz duplex spacing with the uplink in the lower portion and downlink in the upper portion.

Flexibility

- Depending on the actual award outcome there should be a maximum of 2 x 70 MHz of paired spectrum with 50 MHz of unpaired spectrum available between the paired uplink and downlink frequencies (this is fully consistent with the CEPT band-plan in ECC Decision (05)05).

Figure 3: 2.6 GHz band-plan with labelling of blocks #1 to #38.



- The award should allow flexibility to move away from the (05)05 band-plan by allowing the amount of unpaired spectrum to expand at the expense of paired frequencies. Such expansion should be taken by converting the upper portions of the paired uplink and downlink frequencies in equal parts to unpaired use (i.e. from 2570 MHz / block #14 and 2690 MHz / block #38 downwards).

Adjacencies

- The lower 5 MHz block of all unpaired assignments should take the form of a restricted block with more limited transmission rights and for which the risk of interference from neighbouring assignments may be greater.

- Between all paired and unpaired adjacencies there should be a 5 MHz restricted block (which will be the same block as in the bullet above except in the case of block #24 which will automatically be a restricted block provided that block #25 is assigned to paired use) with more limited transmission rights and for which the risk of interference from neighbouring assignments may be greater.

5.9 We set out in the Discussion Document our assessment that:

- the adoption of the main features of the CEPT band-plan would allow the benefits of harmonisation to be achieved by supporting a Europe-wide market for

equipment and by allowing roaming of user equipment between countries, even if different countries adopted different divisions of the band between paired and unpaired spectrum;

- if the flexibility led to an unpaired spectrum allocation in the top half of the band (i.e. in the range covered by blocks #25 to #38) then this should not lead to a material increase in interference to the operation of paired, or FDD, systems;

- a restricted block of 5 MHz between adjacent users would give sufficient protection from interference between neighbouring base stations and, moreover, blocks which were next to an FDD / TDD adjacency would not be of materially different value to other blocks within the same paired or unpaired category on account of this adjacency (either because of the impact of additional interference or because of the cost of mitigating additional interference).

5.10 In responses to the December 2006 Consultation and the August 2007 Discussion Document where the packaging proposals were set out:

- there was full support for the choice of the 5 MHz component size for paired and unpaired lots and for the adoption of the 120 MHz duplex spacing for paired lots – and there was no dissent from the view that these would lead to a European market for handsets / terminals (as opposed to the development of UK specific handsets);

- there was a diverse range of opinions on the issue of flexibility, with those stakeholders interested in WiMAX expressing strong support for flexibility, and a number of stakeholders more interested in FDD technologies-

  - expressing strong concerns that if flexibility led to a departure from the CEPT band-plan then this could cause a much more significant level of terminal-to-terminal interference than had been assessed by Ofcom in the Discussion Document; and

  - suggesting that WiMAX deployments could be accommodated in the 2.6 GHz band in a half-duplex mode and that imposing this requirement on WiMAX deployment in any blocks outside of the central 50 MHz (blocks #15 to #24) would be a better solution than allowing a move away from the CEPT band-plan;

- there was a generally high level of support for the use of 5 MHz restricted blocks, although a range of detailed issues and concerns were raised by some stakeholders about the scope for base station to base station interference; we were also urged by a number of stakeholders to take account of the regulatory work being undertaken in the CEPT Working Group SE42 which was developing technical conditions for use of the 2.6 GHz band under an EC mandate.

5.11 In light of the responses received, we have given substantial further consideration to the above issues, with a particular focus on:

- base station to base station interference and associated mitigation; and

- the potential extent of terminal-to-terminal interference, notably in cases where the award results in a departure from the CEPT band-plan.

5.12 Before discussing our finalised assessments on these issues we provide a short overview of the different aspects of in-band coexistence of FDD and TDD uses in the 2.6 GHz band.

Overview of in-band coexistence of different uses within the 2.6 GHz band

5.13 One may identify four types of inter-system adjacent-channel interference within the 2.6 GHz band. These include:

a) base station to terminal station interference;

b) terminal station to base station interference;

c) base station to base station interference; and

d) terminal station to terminal station interference.

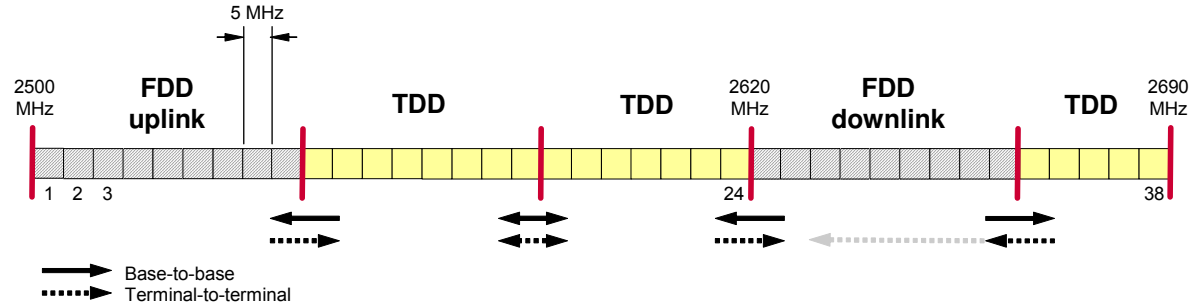
5.14 Categories (a) and (b) above are no different from the types of interference which occur at the frequency boundaries which separate adjacent FDD cellular systems, or indeed, those which separate adjacent TDD cellular systems. Moreover, similar types of intra-system interference occur at the channel boundaries within any type of cellular system. Consequently, no special regulatory provisions for the mitigation of base-to-terminal or terminal-to-base adjacent-channel interference in the 2.6 GHz band are deemed to be necessary (other than those that are already embedded in the relevant technical standards in order to deal with such interference issues).

5.15 Categories (c) and (d) above, however, are specific to scenarios where transmissions in adjacent frequencies are subject to uplink and downlink phases which are not synchronised in time. This is characteristic at frequency boundaries which separate paired (FDD) and unpaired (TDD) spectrum, or at those which separate (uncoordinated) licensees of unpaired (TDD) spectrum.

5.16 Throughout this section and in other parts of this Statement, we refer to 5 MHz blocks (or channels) available in the 2.6 GHz band. Figure 1 above identifies these blocks by numbering them from #1 (2500-2505 MHz) to #38 (2685-2690 MHz). Note that we use the terms “adjacent channel” and “adjacent block” interchangeably to refer to frequency blocks in the vicinity of a block of interest. Where we refer to the block immediately adjacent to a block of interest (i.e. where there is no frequency gap between the two blocks), we use the terms “1st adjacent channel” or “1st adjacent block”.

5.17 Figure 4 below illustrates the frequency boundaries in the 2.6 GHz band where base-to-base and terminal-to-terminal interference would occur for the example of a specific award outcome in which blocks #34 to #38 have, hypothetically, been won by TDD users as unpaired lots.

Figure 4: Frequencies at which base-to-base and terminal-to-terminal interference occur for an illustrative example of a specific award outcome



5.18 The nature of terminal to terminal interference is potentially different across the boundaries illustrated in Figure 4. The Discussion Document focused on the probability of interference from TDD terminal stations operating in the top end of the band (blocks #34 to #38 in the figure) causing blocking of FDD terminal stations in the FDD downlink range. This is because standard FDD terminals made for the European marketplace are likely to have a front-end pass-band filter which allows through signals transmitted at all frequencies in the blocks #25 to #38; hence, interference into FDD terminals from TDD terminals across this top boundary is likely to be greater than interference from TDD terminals operating from below block #24 where the pass-band filter should provide some attenuation. Meanwhile, the interference into TDD terminals will depend on their filter characteristics and on whether adjacent TDD systems are synchronised or not; but, in principle, TDD terminals could receive interference from terminals of other FDD or non-synchronised TDD systems operating anywhere between block #1 and block #24.

5.19 In the following two sub-sections we present a detailed analysis of base-to-base and terminal-to-terminal adjacent-channel interference in the 2.6 GHz band. In the updated analysis reported, we have taken full account of the work of the CEPT Working Group SE42, basing the technical conditions on those recommended in CEPT Report 19, published in December 2007.

Base station to base station interference within the 2.6 GHz band

Introduction

5.20 The potential for base-to-base interference plays a central role in the definition of technical conditions for spectrum use at the frequency boundaries which separate paired (FDD) and unpaired (TDD) spectrum. The same applies at the frequency boundaries which separate licensees of unpaired (TDD) spectrum, where the uplink and downlink phases of the licensees are unsynchronised.

5.21 In the Discussion Document of August 2007, Ofcom set out its views on the impact of base-to-base interference on the packaging of spectrum in the 2.6 GHz award, and presented specific technical conditions for paired and unpaired use of the spectrum.

5.22 Subsequently, a number of modified technical conditions for the 2.6 GHz band were developed by the SE42 project team in response to the EC mandate to CEPT on WAPECS. The resulting CEPT Report 19 was submitted by the ECC chairman to the European Commission in December 2007. As we explained in the Auction Rules Consultation of December 2007, Ofcom will adopt technical conditions for the award of the 2.6 GHz band in the UK that are consistent with the findings in CEPT Report

19. As discussed in Section 3, the RSC has also since agreed a European Commission decision on the 2.6GHz band which is based on CEPT Report 19.

5.23 In this sub-section we first present an evaluation of the necessary frequency separation – between a transmitting base station and a receiving base station – which would allow adequate and viable mitigation of base-to-base interference. This evaluation updates the analysis which we presented in the Discussion Document, taking account of the subsequent work of SE42. We next explain how the results of this evaluation underpin the technical conditions we will adopt for the award of the 2.6 GHz band and the associated implications for spectrum packaging. We finally discuss how the adopted technical conditions relate to specific issues raised by the stakeholders in response to Ofcom's Discussion Document.

Frequency separation and mitigation of base-to-base interference

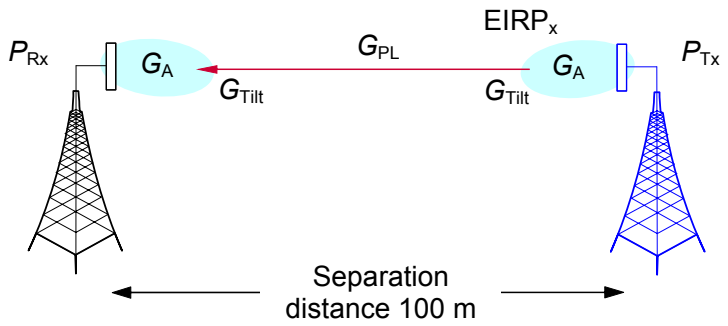
5.24 It is important that the technical conditions for the use of spectrum provide for the adequate protection of base station receivers from potentially interfering base station transmitters, to the extent that any interference mitigation strategies which may be required are both technologically feasible and economically viable.

5.25 Specifically, the technical conditions should not require detailed coordination arrangements between licensees if the relevant base stations have a spatial separation that is greater than a reasonable "coordination distance".

5.26 Note that, for a given spatial separation, base-to-base interference is most severe where transmission powers are high, where the respective antennas have high gains and are within line-of-sight of each another, and where radio propagation conditions approach those of free space. This is likely to be the case for wide-area (macro-cellular) base stations with high antenna placements, resulting in the worst-case geometry depicted in Figure 5.

5.27 Clearly, a requirement for large coordination distances can result in excessive coordination overheads and inefficiencies in network deployment. In accordance with the assumptions of the SE42 project team, a line-of-sight base-to-base separation distance of 100 metres is considered in this document[74].

Figure 5: Base-to-base interference scenario



[74] It can be readily shown that for a mean macro-cell density of $1/\pi$ km^{-2} per licensee (corresponding to a cell radius of 1 km), and independent uniformly distributed base station locations, the probability of a licensee's base station being within 100 metres of a second licensee's base station is approximately 1%. This simple calculation serves to illustrate that a coordination distance of 100 metres should not result in unmanageable administrative overheads.

5.28 For line-of-sight base station separations of less then 100 metres, some form of cooperation between the licensees may be required. This might involve a judicious choice of carrier frequencies and/or antenna orientations, or some other form of mitigation. It should be noted that Ofcom will not be placing a formal coordination obligation on licensees in this respect, rather it is expected that licensees will cooperate voluntarily to minimise the risk of interference when placing base stations close to each other (i.e. closer than 100 metres). Similar cooperative arrangements are in place today in other frequency bands in relation to issues such as base station co-siting.

5.29 The requirements that must be met in order to avoid the need for coordination at separations of 100 metres (and beyond) can be considered with reference to the adjacent-channel interference ratio[75] (ACIR).

5.30 With reference to Figure 5, a minimum coupling loss analysis indicates that an ACIR of no less than 99 dB is required in order for potentially interfering base stations to operate without the need for coordination at a line-of-sight separation of 100 metres. This can be seen by noting that (in the logarithmic domain),

$$\begin{aligned}\mathrm{ACIR} &= P_{\mathrm{Rx}} - P_{\mathrm{I}} \\ &= (\mathrm{EIRP_x} + G_{\mathrm{Tilt}} + G_{\mathrm{PL}} + G_{\mathrm{Tilt}} + G_{\mathrm{A}}) - (P_{\mathrm{N}} + \mathrm{INR}) \\ &= (61 - 3 - 81 - 3 + 17) - (-102 - 6) \\ &= 99\ \mathrm{dB},\end{aligned}$$

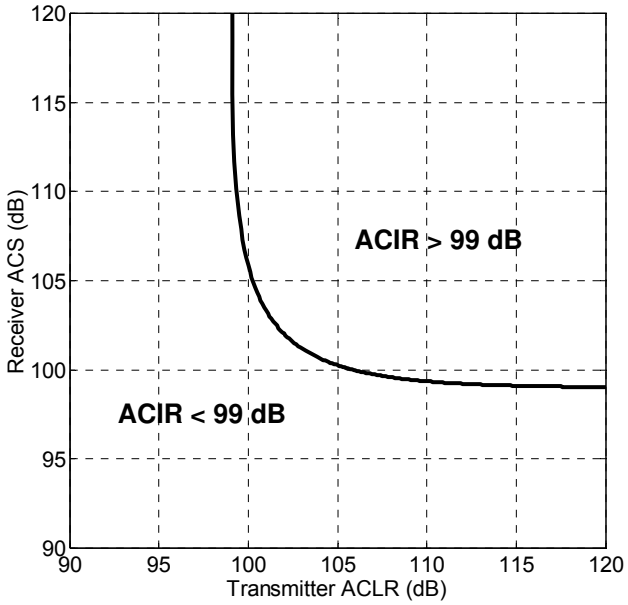
where PRx is the received adjacent-channel interferer power, PI is the "experienced" interference power at the receiver, EIRPx = 61 dBm/(5 MHz) is the interfering base station's in-block mean EIRP (set by SE42 in CEPT Report 19), GTilt = 3 dB represents loss due to antenna tilt at each of the transmitter and receiver, GPL=81dB is free-space path-loss for a separation of 100 metres at 2.6 GHz, GA=17 dBi is the receiver antenna gain, PN=102 dBm/(5 MHz) is the receiver noise floor (for a nominal receiver bandwidth of 5 MHz and noise figure of 5 dB), and finally, INR=6 dB is the interference-to-noise ratio for a 1 dB receiver desensitization. Note that a 1 dB desensitization implies an experienced interference power of 108 dBm/(5 MHz) or 115 dBm/MHz.

5.31 The required ACIR of 99 dB can be achieved through various combinations of transmitter adjacent-channel leakage ratio (ACLR) and receiver adjacent-channel selectivity (ACS)[76], although the values of ACS and ACLR would each need to be greater than or equal to 99 dB. The possible trade-offs between ACLR and ACS are illustrated in Figure 6 for an ACIR of 99 dB.

[75] The ACIR is defined as the ratio of the power of an adjacent-channel interferer as received at the victim, divided by the interference power "experienced" by the victim receiver as a result of both transmitter and receiver imperfections.

[76] The ACLR of a signal is defined as the ratio of the signal's power divided by the power of the signal when measured at the output of a (nominally rectangular) receiver filter centred on an adjacent frequency channel. The ACS of a receiver is defined as the ratio of the receiver's filter attenuation over its passband divided by the receiver's filter attenuation over an adjacent frequency channel. It can be readily shown that $\mathrm{ACIR}^{-1} = \mathrm{ACLR}^{-1} + \mathrm{ACS}^{-1}$.

Figure 6: Trade-offs between ACLR and ACS for an ACIR of 99 dB



5.32 The technological feasibility and economic viability of achieving an ACIR of 99 dB is a function of the frequency separation between the transmitting and receiving base stations.

5.33 To illustrate this point, Figure 7 below plots the values of ACLR and ACS for the baseline transmit and receive minimum requirements[77] implied in 3GPP TS 25.104 for UTRA FDD wide-area base stations at the 1st, 2nd, and 3rd adjacent (5 MHz) channels. As can be seen from Figure 7, the 3GPP minimum requirements do not meet the ACIR requirement of 99 dB at any of the three adjacent channels considered. In other words, additional transmit and receive filtering beyond the minimum that is specified for 3GPP-compliant base stations would be necessary to meet the 99 dB ACIR target. In particular:

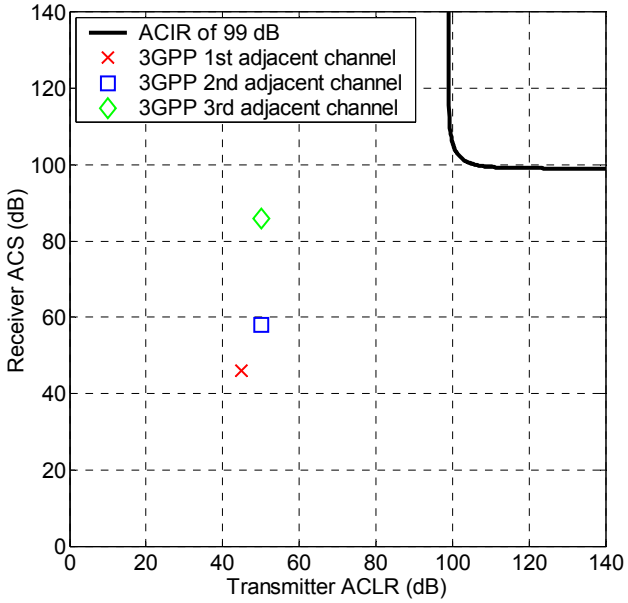
- compared to the 3GPP minimum requirements for ACLR, the transmit filter at the interfering base station needs to provide additional stop-band attenuations of at least 54 dB and 49 dB at the 1st and 2nd adjacent channels respectively;
- compared to the 3GPP minimum requirements for ACS, the receiver filter at the interfered base stations needs to provide additional stop-band attenuations of at least 53 dB, 41 dB, and 13 dB at the 1st, 2nd, and 3rd adjacent channels respectively.

5.34 It should be pointed out that the above computed values somewhat over-estimate the additional filter stop-band attenuations that are required, by comparison with current practice, for the mitigation of interference. This is because the additional attenuations

[77] (ACLR, ACS) values in dB of (45,46) at the 1st adjacent channel (5 MHz offset), (50,58) at the 2nd adjacent channel (10 MHz offset), (50,86) at the 3rd adjacent channel (15 MHz offset), and (50,114) at the 4th adjacent channel (20 MHz offset), are derived from Sections 6.6.2.2, 7.4, and 7.5 of 3GPP TS 25.104. The ACS at the 3rd adjacent channel is derived by linear interpolation between the ACS values at the 2nd and 4th adjacent channels. Note that 3GPP does not specify minimum requirements for ACLR at the 3rd and 4th adjacent channels. We (pessimistically) use the same ACLR of 50 dB at the 3rd and 4th adjacent channels as specified by 3GPP at the 2nd adjacent channel.

are expressed with reference to the 3GPP minimum requirements for ACLR and ACS, whereas, in practice, 3G base stations readily exceed these minimum requirements. Nevertheless, we believe that the computed values serve as useful guidelines for assessing the technological feasibility of filtering requirements in the 2.6 GHz band.

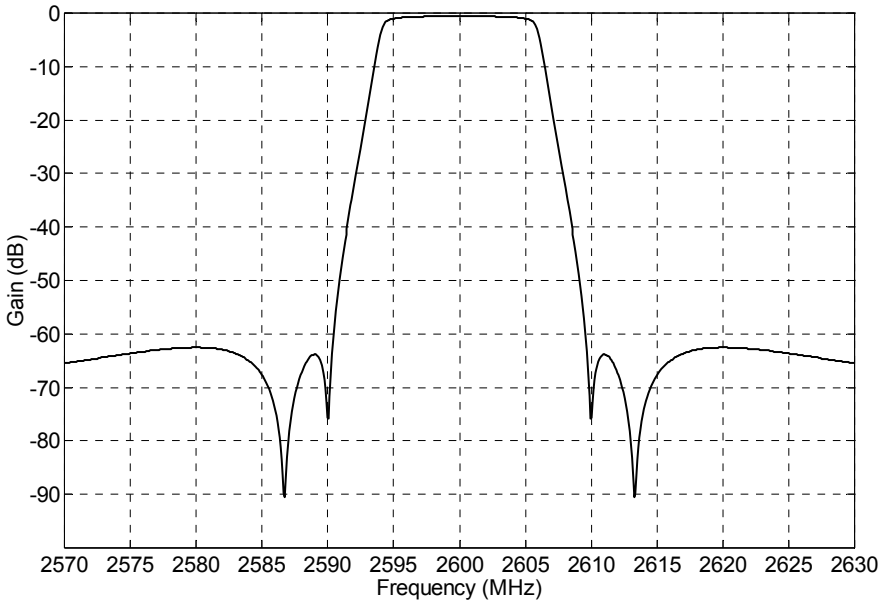
Figure 7: Comparison with ACLR and ACS minimum requirements in 3GPP TS 25.104 for UTRA-FDD wide-area base stations at different adjacent channel offsets



5.35 A transmit or receive filter stop-band attenuation of the order of 50 to 55 dB in the 1st adjacent channel would be extremely challenging (if at all feasible) without significant insertion loss at the pass-band edges. It can therefore be concluded that the mitigation of 1st adjacent-channel base-to-base interference caused by a high-power base station is not readily achievable in the geometry considered.

5.36 However, information obtained by Ofcom from a number of filter manufacturers suggests that stop-band attenuations of the order of 60 dB are readily achievable at the 2nd adjacent channel (i.e. beyond 5 MHz from the pass-band edge). RF transmit and receive filters with such performance based on conventional and ceramic resonator technologies are commercially available today. This is illustrated in Figure 8 which shows the frequency response of a 6-pole ceramic filter with a pass-band of 10 MHz, and an insertion loss of 0.6 dB.

Figure 8: Frequency response of a 6-pole ceramic filter. Such filter performance is required for the mitigation of 2nd adjacent channel base-to-base interference



5.37 We therefore conclude that, for the geometry considered (involving a separation of 100 metres between base stations), transmit and receive filtering for the mitigation of 2nd adjacent-channel base-to-base interference caused by a high-power base station is technologically feasible.

5.38 At the time we published the Discussion Document, we indicated that, as a coarse estimate, the cost of such filters might be of the order of £500. Since then, SE42 has completed its work on base station block edge masks (BEMs) for the 2.6 GHz band and has specified a limit of –45 dBm/MHz in the 2nd adjacent channel (consistent with meeting the ACIR target of 99 dB). The implication of this emission limit is that operators across Europe wishing to use the 2.6 GHz band would need to apply the additional levels of filtering quantified above to their base station emissions. Accordingly, we would expect the market for these filters to be Europe-wide, rather than UK-specific. Manufacturers have also indicated that, if produced in the kind of volumes required to satisfy European demand, the price of such additional filtering would be of the order of £100 to £200. On this basis, for two transmit and two receive branches per sector, the price of additional filters per-carrier per-sector would amount to between 2% and 4% of the per-carrier per-sector price of hardware for a wide-area 3G NodeB[78].

5.39 We therefore conclude that, for the geometry considered (involving a separation of 100 metres between base stations), transmit and receive filtering required for the mitigation of 2nd adjacent-channel base-to-base interference caused by a high-power base station is not only technologically feasible, but is also economically viable. Our analysis also suggests that the filtering requirements for mitigation of 3rd adjacent-

[78] It is difficult to derive a definitive figure for the price of base station hardware. However, internal studies by Ofcom suggest a price of around £20k for a 1-sector 1-carrier wide-area UTRA-FDD NodeB. It might also be noted that the cost of base station hardware typically accounts for only 30% to 40% of the cost of the wireless network infrastructure.

channel base-to-base interference (and beyond) represent relatively modest improvements over that which is already achieved in 3G base stations today.[79]

5.40 The above results form the basis for the technical conditions and BEMs adopted by Ofcom for the 2.6 GHz band. These are discussed next.

Impact on adopted technical conditions and spectrum packaging

5.41 The analysis outlined in the previous sub-section implies that the minimum edge-to-edge frequency separation between bocks which contain high-power FDD base stations and those which contain high-power TDD base stations need be no more than 5 MHz. Moreover, the modest cost of filtering on the receiving base station means that it will be economically and technically efficient to require no more than this 5 MHz separation in the way that we package the 2.6 GHz band for award. The alternative of requiring a 10 MHz separation might marginally reduce deployment costs associated with filtering, but it would do so at the significant cost of leaving 5 MHz more spectrum under-used at each adjacency.

5.42 As a result, a 5 MHz "restricted" block will be mandated at every frequency boundary which separates a paired (FDD) block from an unpaired (TDD) block in the 2.6 GHz band. Base station transmissions in these restricted blocks will still be permitted, but at a significantly reduced EIRP.

5.43 As noted before, there is also a potential for base-to-base interference at the frequency boundaries which separate licensees of unpaired (TDD) spectrum whose uplink and downlink phases are not synchronised. The same arguments apply here with regards to the need for a 5 MHz edge-to-edge separation. Consequently, a 5 MHz "restricted" block will be mandated at every frequency boundary which separates licensees of unpaired (TDD) spectrum in the 2.6 GHz band.

5.44 The positions of the restricted blocks are indicated in Figure 9 below for an illustrative example of a specific award outcome, along with the relevant base station BEMs and in-block EIRPs. Further details of the adopted BEMs are provided in Section 6 of this document and they are fully set out in the Information Memorandum published alongside this Statement.

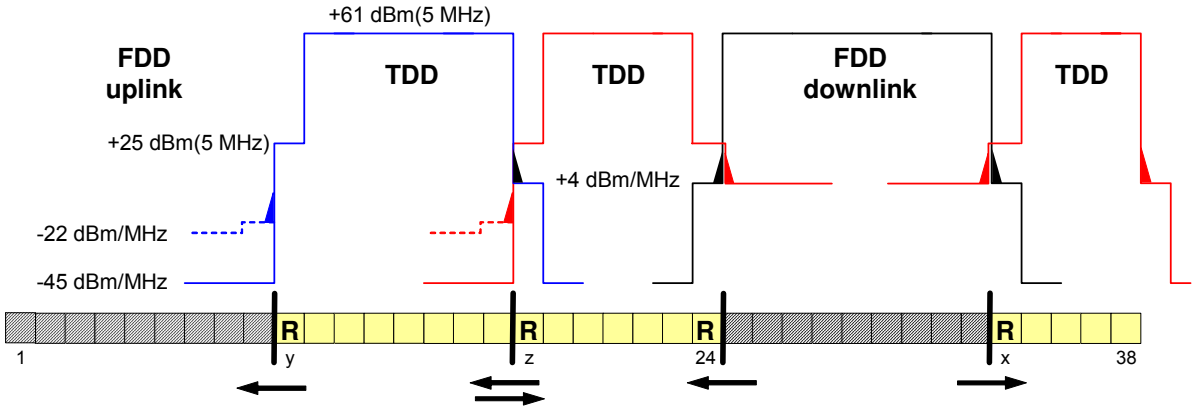
5.45 For the purposes of packaging spectrum for award, the restricted 5 MHz block at each frequency boundary separating paired (FDD) and unpaired (TDD) spectrum (i.e. blocks #24, "x", and "y" in Figure 9) will be part of the unpaired (TDD) spectrum assignments. Furthermore, at boundaries separating licensees of unpaired (TDD) spectrum (i.e. block "z" in Figure 9), the restricted 5 MHz blocks will be associated with the higher-frequency licensee. This configuration is intended not only to manage the risk of base-to-base interference between users of adjacent spectrum[80], but also to present a consistent set of requirements to all who bid for a given spectrum category. That is to say, packages of paired spectrum will not include a restricted

[79] It is also possible that it might be more cost effective for filter manufacturers to make all filters for 2.6 GHz base station use to one standard (which would be to the highest specification required), rather than to create smaller production runs for filters with differing specifications.

[80] Note that base stations in the two restricted unpaired (TDD) blocks on either side of the paired (FDD) downlink blocks do not actually cause base-to-base interference. However, these two restricted blocks serve to protect the TDD base stations in adjacent standard blocks from interference caused by FDD base stations.

block, while each contiguous package of unpaired spectrum will include a restricted block as its lowest frequency block[81] as illustrated in Figure 9.

Figure 9: Restricted blocks and base station BEMs for the example of a specific award outcome. Arrows indicate direction of base-to-base interference. Restricted blocks are marked with "R". Dashed lines indicate relaxed BEMs



5.46 A number of key features associated with the technical conditions and resulting spectrum packaging of the 2.6 GHz band are as follows.

i) A base station in-block mean EIRP[82] of 61 dBm/(5 MHz) will apply for all standard blocks. This is in line with the transmission power of 43 dBm/(3.84 MHz) specified in 3GPP TS 25.104 for wide-area base stations (given an antenna gain of 17 dBi).

ii) A reduced base station in-block mean EIRP of 25 dBm/(5 MHz) will apply for all restricted blocks. This serves to mitigate the impact of potential base-to-base interference between standard blocks across frequency boundaries which separate paired (FDD) and unpaired (TDD) spectrum, or across those which separate licensees of unpaired (TDD) spectrum.

iii) Where there is a possibility of base-to-base interference into a standard block (i.e. from blocks "y" and "z" in Figure 9), the interfering base station will be subject to a "baseline" BEM which falls to –45 dBm/MHz in the adjacent channel. This corresponds to an ACLR of 99 dB for high-power base stations, and as discussed earlier, is a requirement for uncoordinated deployments at spatial separations greater than 100 metres.

iv) The SE42 project team observed that the baseline emission limit of –45 dBm/MHz is unnecessarily stringent given the highly reduced in-block EIRP of the TDD base stations operating in restricted blocks, and that a relaxation of the BEM is possible without a material increase in the likelihood of base-to-base interference. The relaxed BEM broadly follows the emissions mask specified in TS 25.104 for local-area base stations (for an antenna gain of 3 dBi). Such a relaxation would be subject to restrictions on maximum outdoor and indoor

[81] In order to maintain this consistency, the restricted unpaired (TDD) block #24 will not be included in the Principle Stage of the auction.
[82] All emission limits correspond to aggregate radiated power from a base station sector.

antenna heights above ground level of 4 and 10 metres respectively.[83] The relaxed BEMs are shown as dashed lines in Figure 9.[84]

v) Where there is a possibility of base-to-base interference into an adjacent restricted block (i.e. where TDD base stations receive and can be the victim of adjacent channel interference, namely, into blocks 23, "x" and "z" in Figure 9), the interfering base station will be subject to a "baseline" BEM which falls to +4 dBm/MHz in the adjacent channel. This is in line with the emission mask specified in 3GPP TS 25.104 for wide-area base stations (for an antenna gain of 17 dBi).

vi) In all other cases (i.e. the two unpaired (TDD) blocks on either side of the paired (FDD) downlink blocks, namely, blocks #24 and "x" in Figure 9), base stations will be subject to "baseline" BEM which falls to +4 dBm/MHz in the adjacent channel.

vii) All BEMs extend out to 30 MHz past the upper and lower edges (i.e. 2500 and 2690 MHz) of the 2.6 GHz band, down to 2470 MHz and up to 2720 MHz, to help manage the risk of interference to users in neighbouring spectrum bands as explained later in this section.

5.47 Note that, as a result of the adopted technical conditions and spectrum packaging, restricted blocks are not protected from base-to-base interference to the same extent as standard blocks. In other words, the usability of restricted blocks is defined by both the restrictions on base station transmission rights, and by the limited nature of their protection from interference.

5.48 In cases where licensees choose to coordinate (including the case of synchronisation among TDD networks), such coordination could include an agreement to enable restricted blocks to be operated as standard blocks. In addition, if licensees choose to coordinate and agree, they can request a relaxation of the BEMs within each others' respective blocks. Naturally, the above options for relaxation of the technical conditions also apply at boundaries between FDD and TDD spectrum belonging to the same licensee. Where licensees agree such relaxation of the technical conditions they would need to ask Ofcom to vary their licences accordingly. In such cases Ofcom would expect to agree to such a request provided it was satisfied that no other parties were adversely affected.

[83] According to the extended-Hata (urban) model, at distances greater than 100 metres from a 30 metre high receiver, each extra 1 metre of transmitter height from near ground level equates approximately to a 3 dB reduction in mean path-loss. Coupling loss analysis then indicates that, subject to a maximum outdoor antenna height of 4 metres, a TDD base station with a relaxed BEM operating in a restricted block (in-block EIRP of 25 dBm/(5 MHz), ACLR of 34 dB), would cause no greater interference toward an adjacent channel base station than would an outdoor terminal station (in-block EIRP of 31 dBm/(5 MHz), ACLR of 32 dB) operating in the same block at a height of 1.5 metres. The maximum indoor antenna height of 10 metres serves to prevent situations where large numbers of low-power base stations operating in restricted blocks might appear within near line-of-sight of outdoor base stations operating in adjacent standard blocks. The increase of 6 metres compared to the outdoor case is consistent with the assumption of an additional path loss of 18 dB, made up from a combination of losses within buildings and losses through the outer skin of buildings.

[84] The relaxations in the BEMs (subject to limits on antenna height) have been described here in the context of base stations operating in unpaired (TDD) restricted blocks. Note that the same relaxations in the BEMs (subject to similar limits on antenna height) also apply to low-power base stations (i.e. those with maximum in-block mean EIRP of 25 dBm/(5 MHz)) operating in standard unpaired (TDD) or paired (FDD) blocks.

5.49 Finally, we note that the ability to mitigate base-to-base interference means that there are no grounds for standard 5 MHz blocks within a given category (i.e. paired or unpaired) in the 2.6 GHz band to have different degrees of usability. In addition, the modest cost of filtering should mean that it will not be materially more expensive to deploy base stations in blocks near frequency boundaries which separate paired (FDD) and unpaired (TDD) spectrum, or which separate licensees of unpaired (TDD) spectrum, than it is to deploy base stations in other blocks.

Stakeholder responses on base-to-base interference in the 2.6 GHz band and Ofcom's views on the issues raised

5.50 In this sub-section we present a detailed review of stakeholder responses to the Discussion Document of August 2007 which relate to the issue of base-to-base interference. While a number of stakeholders have expressed support for our analysis and proposals, for each topic, we cite statements of concern from various stakeholders, followed by a clarification of our views on the issues raised.

5.51 Qualcomm noted that: "Ofcom's studies assume that the level of the TDD ACI is of the order of the thermal noise floor. This results in 3dB UMTS Rx desensitization", and that: "Rx desensitization of 1dB is a more acceptable assumption".

- **Ofcom's view** – We agree. The updated analysis assumes a 1 dB desensitization.

5.52 One respondent argued that: "…the blocking effects from FDD base stations to TDD base stations have not been assessed…", and that: "…it may be required to add a suitable guard-band in order to resolve the blocking problems that may arise from FDD base stations to TDD base stations".

- **Ofcom's view** – As demonstrated in this document, the use of additional RF transmit and receive filtering, in conjunction with a 5 MHz restricted block, will mitigate the impact of base-to-base interference. Furthermore, it can be readily shown that[85] it is the signal-to-interference ratio (i.e. limited ACIR), rather than receiver saturation or blocking, which is the dominant factor.

5.53 A number of stakeholders, including Nortel and Urban WiMAX, questioned the technological viability of the filters required for mitigation of base-to-base interference. Urban WiMAX stated that: "…at this time we are not aware of any filter having been designed and tested with the required performance".

- **Ofcom's view** – Note that the existence of a 5 MHz restricted block between wide-area transmitting and receiving base stations significantly relaxes the filtering requirements. As described earlier, Ofcom has discussed these requirements with a number of RF filter manufacturers. The feedback suggests that stop-band attenuations of 60 dB or more at the 2nd adjacent channel with insertion losses of around 0.6 dB are readily achievable via conventional (silver-plated Aluminium) or ceramic resonator technologies.

[85] Given the parameters specified in paragraph 5.46, the interferer power at the receiver's RF filter input would be 61−3−81−3+17 = −9 dBm/(5 MHz). For a filter stop-band attenuation of 60 dB at the 2nd adjacent channel, the interferer power at the receiver's RF filter output would be −69 dBm/(5 MHz). This is considerably less than the −40 dBm/(3.84 MHz) blocking level (at frequency offset of 10 MHz) specified in 3GPP TS 25.104 for UTRA FDD wide-area base stations.

5.54 One respondent argued that: "…additional filtering will be a significant cost to a network operator in the band adjacent to TDD systems. For a roll-out of 7000 sites, Ofcom estimates an additional cost of approximately £20 million", and that: "…it is unclear whether £20 million will be a significant cost for any individual network operator that wins the spectrum. Therefore there should be a mechanism in the primary round for operators to differentiate their bids depending upon whether or not they will have to face this cost".

- **Ofcom's view** – Information obtained by Ofcom from filter manufacturers suggests a filter price (for 2 Tx and 2 Rx branches) in the range of £400 to £800 per-carrier per- sector. This amounts to 2% to 4% of the per-carrier per-sector price of a 3G NodeB (estimated to be somewhere around £20k). Consequently, Ofcom believes that the cost of base station equipment in blocks near the frequency boundaries which separate paired (FDD) and unpaired (TDD) spectrum, or near those which separate licensees of unpaired (TDD) spectrum, is not significantly different from that in other blocks. Therefore, this is not a reason for different standard blocks to have to be differentiated in the Principal Stage of the auction.

5.55 On the question of extending the out-of-block masks to ±20 MHz from the block edges, a large majority of respondents were in agreement with Ofcom's proposal. Those who disagreed either saw no benefit in extending the masks beyond the original ±10 MHz, or suggested that this may incur additional costs.

- **Ofcom's view** – Ofcom proposes to broadly adopt the technical conditions developed by SE42 for the 2.6 GHz band. Consequently, the BEMs will be extended all the way to the upper and lower edges of the 2.6 GHz band (i.e. 2500 and 2690 MHz). In fact, to help manage the risk of interference to users in neighbouring spectrum bands, we intend to extend the BEMs down to 2470 MHz and up to 2720 MHz. It should be pointed out that such extensions of the masks do not result in additional costs. This is because any incremental costs associated with filtering are almost entirely due to the mask values in the first 10 MHz from the block edges.

5.56 On the question of additional restrictions on the use of the restricted block between FDD uplink and TDD, there was a more or less even split between those who agreed and those who did not. A number of issues were raised by the stakeholders, as described next.

5.57 Certain stakeholders, including BT, Inquam, Intel, Motorola, Nortel, Samsung, and the WiMax Forum disagreed with the reduction of base station in-block EIRP to 25 dBm/(5 MHz) in restricted blocks and/or the placing of additional restrictions on the use of the restricted blocks. This was generally on the grounds that the proposed restrictions would severely limit the use of the restricted blocks.

- **Ofcom's view** – Based on the analysis presented in this document, Ofcom believes that the mitigation of 1st adjacent-channel base-to-base interference caused by high-power base stations would require either prohibitive coordination distances, or techno-economically unviable RF filtering at both the transmitters and receivers. As a result, a 5 MHz restricted block with reduced in-block emission limits is a necessity at all frequency boundaries which separate paired (FDD) and unpaired (TDD) spectrum, or at those which separate licensees of unpaired (TDD) spectrum. See Figure 9.

5.58 On the contrary, a stakeholder stated: "We strongly support the proposal to reduce the in-block power of base stations to 18 dBm/MHz EIRP within the restriction block between the FDD uplink and TDD. We also believe that this restriction should be applied to the blocks between TDD operators where synchronisation is not possible".

- **Ofcom's view** – We agree. A base station in-block mean EIRP of 25 dBm/(5 MHz), equivalent to 18 dBm/MHz, will apply in all 5 MHz restricted blocks between unpaired (TDD) licences.

5.59 Two respondents expressed concerns regarding base-to-base interference at adjacencies between TDD and FDD downlink. One argued that: "…a restricted block should also be defined at the FDD downlink / TDD boundary in order to protect the TDD base station receiver". The other stated that: "…we would therefore propose that these blocks are either true guard bands or restricted to downlink only".

- **Ofcom's view** – We agree that TDD base stations require adequate protection from adjacent-channel FDD base stations. As a result, a 5 MHz restricted block will be applied at frequency boundaries which separate paired (FDD) downlink blocks from unpaired TDD blocks. For reasons explained in paragraph 5.45, the restricted blocks will be associated with unpaired (TDD) spectrum assignments, and a base station in-block mean EIRP of 25 dBm/(5 MHz) will also apply. Note there is no need for these restricted blocks to be "true" guard-bands, since the base stations therein do not cause interference towards adjacent-channel FDD base stations.

5.60 One of the respondents further argued that: "…it will be necessary to place additional conditions on the use of restricted blocks between the FDD uplink and TDD", and that: "the use of the restricted block by an outdoor TDD base station will create significant interference to FDD uplink performance. Nor is it as simple as seeking to restrict TDD base stations operating in the restricted block for indoor use because this would also prevent the FDD base station from being installed in any indoor area where such a TDD base station is located. Furthermore, whenever a TDD base station operating within the restricted block is installed at higher levels within a building, it would be likely to create interference problems for any FDD base stations installed on the rooftops of nearby buildings".

- **Ofcom's view** – The potential for interference from low-power TDD base stations needs to be considered in the appropriate context. We note that base stations in paired (FDD) blocks that are not adjacent to an unpaired (TDD) restricted block experience interference from FDD terminals operating in both the upper and lower adjacent channels. Such terminals may transmit at mean EIRP levels of up to 31 dBm/(5 MHz) with an ACLR of 32 dB at the 1st adjacent channel.

- By comparison, a base station in a restricted unpaired (TDD) block, will transmit at a mean EIRP level of 25 dBm/(5 MHz) with an ACLR of 63 dB at the 1st adjacent channel (assuming the baseline BEM of –45 dBm/MHz applies). Here, the ACIR is dominated by the FDD base station ACS of at least 46 dB. This implies that, for similar geometries, a low-power TDD base station subject to the baseline BEM would cause 20 dB less interference than would an FDD terminal station. Given the low potential for interference, we do not believe any additional restrictions need to be placed on the operation of TDD base stations in restricted blocks where the baseline BEM applies.

- However, where the relaxed BEM applies (see dashed lines in Figure 9), a TDD base station in a restricted block can transmit at a mean EIRP level of 25 dBm/(5

MHz) with an ACLR of 34 dB. This implies that, for similar geometries, a TDD base station in a restricted block and radiating with a relaxed BEM would cause only 8 dB less interference than would an FDD terminal station. It follows that[86], with an antenna height of 4 metres, an outdoor TDD base station in a restricted block would cause broadly the same amount of interference as would an FDD terminal (height of 1.5 metres). Based on this evaluation, we believe it is prudent to place a limit of 4 metres on the maximum outdoor antenna height of TDD base stations in restricted blocks where the relaxed BEM applies.

- In addition, we will place a limit of 10 metres on the maximum indoor antenna height of TDD base stations in restricted blocks where the relaxed BEM applies. The increase of 6 metres compared to the outdoor case is consistent with the assumption of an additional path-loss of 18 dB (made up from a combination of typical losses within buildings and losses through the outer skin of buildings). The adopted limit will serve to prevent situations where large numbers of low-power TDD base stations in restricted blocks might appear within near line-of-sight of outdoor FDD base stations in adjacent standard blocks.

- Note that similar arguments regarding relaxed TDD base station BEMs in restricted blocks and the need for antenna height limits apply where the potential victim is a (unsynchronised) TDD base station in an adjacent standard block.

5.61 Stakeholders also raised a number of issues not directly related to the specific questions posed in the Discussion Document of August 2007.

5.62 A number of concerns were raised regarding the units in which in-block EIRPs are expressed. Motorola commented that: “In-band power limitation expressed in terms of PSD would be disadvantageous for narrowband systems. In-band limitations could be better specified in terms of a maximum transmit power within the nominal channel” and that: “For addressing the radiated performance of the user equipment, an additional parameter of Transmitted Radiation Power (TRP), which is also used by 3GPP, could be defined”.

- **Ofcom’s view** – We agree with both points. In line with developments in SE42, in-block EIRPs will be specified in units of dBm measured over a nominal bandwidth of 5 MHz, written as dBm/(5 MHz). TRP will also be used to define terminal station radiated power.

5.63 BT commented on the need “to clarify the definition of maximum mean EIRP limits in terms of the measurement period to be considered when determining the mean value. This question is important because TDD systems will have a certain Tx/Rx duty cycle and also because OFDM can have a large peak-to-mean power ratio across a transmit symbol. To address this issue BT requests that Ofcom clarifies that the maximum mean EIRP shall be measured considering a nominal measurement period of one second”.

- **Ofcom’s view** – We agree that some clarification is necessary. Where technologies are deployed that actively transmit in bursts (e.g. TDD technologies) then all emission limits shall be applied to the active part of the transmission. This is a common approach adopted in specifying regulation for discontinuous transmissions.

[86] According to the extended-Hata (urban) model, at distances greater than 100 metres from a 30 metre high receiver, each extra 1 metre of transmitter height from near ground level equates approximately to a 3 dB reduction in mean path-loss.

5.64 BT also noted that: "a general point concerning EIRP limits is how the possible use of MIMO techniques and beam forming using arrays of antenna transmitting elements", and stated that: "we assume that the licensed maximum EIRP is understood to be that EIRP in any direction from the base station that would be derived from a far field measurement of received power at a known distance and known measurement receiver antenna gain. So long as the EIRP limit so defined is sufficiently high to allow for MIMO / beam forming antennas we do not see a need for special regulations to address this issue".

- **Ofcom's view** – We agree that it is necessary to provide further clarification on how the emission limits apply to multiple-antenna installations. CEPT Report 19 provides a description of the application of conditions to base stations with multiple transmit antennas that we believe is appropriate to apply in the case of this award:

> *"This section describes how technical conditions defined in terms of EIRP can be applied to base stations with more than one antenna (or separately fed antenna element) serving the same geographic area. It is assumed that the normal method of verification of these conditions will be by calculation (taking the rated transmitter parameters, adding the antenna gain and subtracting the feeder and other losses).*
>
> *In cases where the inputs to different antennas are not correlated, the EIRP for each antenna can be calculated separately and then summed – this applies for MIMO, transmit diversity and "antenna combining" (where different transmitter channels are fed to different branches of a diversity antenna system).*
>
> *In cases where the inputs to different antennas or antenna elements are correlated, such as adaptive or beam forming arrays, the following methodology can be used:*
>
> $EIRP_{effective} = \Sigma P_{nom}$ *(dBm)* + 10 log 180/θ + *10 log 360/φ*
>
> *Where:*
>
> > ΣP_{nom} *is the sum of the nominal maximum powers of the transmitter outputs feeding each element, measured at the antenna port;*
> >
> > θ *is the -3dB beamwidth of the antenna array in the vertical plane (if this beamwidth can vary, the minimum value should be used); and*
> >
> > *φ is the angle in the horizontal plane for which the antenna system is intended to provide service*[87]*.*
>
> *This methodology assumes that, averaged over time, the power radiated by the antenna system is spread evenly over its angle of operation.*
>
> *It should be noted that the adjacent channel emissions from an antenna array will not have the same directional properties as the in-band signal, and they will generally be much less directive. This is because the adjacent channel emissions are largely cause by inter-modulation products, for*

[87] For example, in an antenna system that is intended to provide 360° coverage with four arrays, this angle would be 90°.

which the amplitude is not linearly related to the in-band signal, and the phase is only weakly correlated".

Conclusions on base-to-base interference

5.65 In this part of Section 5, dealing with the issue of base-to-base interference in the 2.6 GHz band, we have concluded that:

a) an edge-to-edge frequency separation of 5 MHz is required at frequency boundaries which separate paired (FDD) and unpaired (TDD) blocks, or at those which separate licensees of unpaired (TDD) spectrum, in order to allow technologically viable mitigation of base-to-base interference via transmit and receive filtering;

b) the cost of the required filtering (above and beyond that implemented today in 3G base stations) would be a small percentage of the total cost of base station equipment, even for multiple transmit and receiver branches per sector;

c) the spectrum between the standard blocks which have the edge-to-edge frequency separation of 5 MHz can still be used as 5HMz restricted blocks; and

d) all standard blocks within a given category (i.e. paired or unpaired) will have a similar utility and that no specific block will require network equipment that is substantially more expensive than others.

Terminal station to terminal station interference within the 2.6 GHz band

Introduction

5.66 There is a potential for terminal-to-terminal interference across frequency boundaries which separate paired (FDD) and unpaired (TDD) spectrum, or across those which separate licensees of unpaired (TDD) spectrum where the uplink and downlink phases of the licensees are likely to be unsynchronised.

5.67 In the Discussion Document, Ofcom set out its views on the subject of terminal-to-terminal blocking[88] and its effect on the use of the 2.6 GHz spectrum. This described details of our computer simulations which evaluated the scale of this blocking effect and the resulting potential for interference from TDD terminal stations to FDD terminal stations on the basis of the minimum requirements set out in the 3GPP Specifications. Our analysis suggested that, subject to plausible assumptions, the fraction of FDD terminal stations which might suffer from blocking would be broadly similar to that which suffered from lost or failed connections due to the normal operation of the FDD cellular network regardless of other use of adjacent spectrum. It indicated that the level of interference would be more significant in "hot-spots" where an FDD terminal was being used in the proximity of a very high density of active TDD users (such as in a conference centre). However, a number of mitigation factors were discussed that could reduce the significance of interference in these hot-spot scenarios.

5.68 We received strong views from some stakeholders with regards to our assessment of terminal-to-terminal interference. While a number of stakeholders agreed with Ofcom's conclusions, others were not persuaded by our analysis and argued that the

[88] The issue of terminal-to-terminal adjacent-channel interference had been addressed earlier in the December 2006 Consultation.

presented technical conditions for paired and unpaired use of the spectrum did not provide adequate means for mitigation of terminal-to-terminal interference. One stakeholder suggested that Ofcom should carry out further work, including some empirical measurements. A number of stakeholders argued that Ofcom should consider an analysis of terminal-to-terminal adjacent channel interference as well as an analysis of blocking. However, those stakeholders who consistently expressed concerns about terminal-to-terminal interference have provided very limited (if any) analysis of their own in support of their views, despite having been aware of this issue since the publication of the first consultation in December 2006.

5.69 Subsequent to the publication of Ofcom's Discussion Document, a number of technical conditions for the use of the 2.6 GHz band were developed by the SE42 project team and published in CEPT Report 19. These conditions include terminal station in-block EIRP and block-edge masks (BEMs) that are similar to those assumed by Ofcom in its Discussion Document, and as such, do not alter our conclusions on terminal-to-terminal interference. As we explained in the Auction Rules Consultation of December 2007, we propose to adopt technical conditions for the award of the 2.6 GHz band in the UK that are consistent with the findings of CEPT Report 19. Accordingly, Ofcom remains confident that the adopted technical conditions and spectrum packaging will adequately manage the risk of terminal-to-terminal interference in the 2.6 GHz band.

5.70 However, in order to address stakeholder concerns Ofcom has undertaken further complementary analysis[89] of the interference caused by TDD terminal stations towards FDD terminal stations and its impact on FDD downlink throughput. This further work looks specifically at the effects of interference in hot-spots, using realistic characterisations of terminal station behaviour drawn from a short study commissioned for this purpose. The analysis also:

- takes into account of the impact of adjacent-channel interferers in relation to a) radiation masks and non-ideal receiver filter characteristics, b) non-linear effects at the receiver, and c) receiver blocking (or saturation);
- examines the effects of interference in pico-cellular as well as in macro-cellular network deployments; and
- reflects the performance of commercially available UTRA-FDD user equipment, as derived through measurements commissioned by Ofcom[90], as opposed to the minimum requirements set out in the 3GPP Specifications (which were defined over 10 years ago).

5.71 In the sub-sections that follow, we:

- provide an overview of the terminal station transceiver characteristics that are used in the analysis of terminal-to-terminal interference;

[89] Ofcom, "On the impact of interference from TDD terminal stations to FDD terminal stations in the 2.6 GHz band," final report, April 2008. A link to this document will be available at http://www.ofcom.org.uk/radiocomms/spectrumawards/ when it is published.

[90] ERA Technology, "Measurements of UTRA-FDD user equipment characteristics in the 2.1 GHz band," final report, April 2008. A link to this document will be available at http://www.ofcom.org.uk/radiocomms/spectrumawards/ when it is published.

- summarise the main results from our evaluation of terminal-to-terminal interference, and explain their implications in the context of the technical conditions and spectrum packaging adopted by Ofcom for the 2.6 GHz band; and

- discuss stakeholder feedback and questions regarding Ofcom's assessment of terminal-to-terminal interference as published in the Discussion Document, and elaborate on how the issues raised haven been addressed in our more recent analysis.

Radio characteristics of terminal stations relating to adjacent-channel interference

5.72 The scope for terminal-to-terminal adjacent-channel interference is driven by a mix of factors relating to:

a) the experienced interference as a result of radiation spectral leakage and non-ideal receiver filter characteristics (i.e. limited ACIR);

b) third-order inter-modulation products, which represent the interference caused by non-linear behaviour at the receiver; and

c) saturation, or "blocking", where a terminal station becomes overloaded by the high power levels of received adjacent-channel interferers which prevent the receiver from processing the wanted signal.

5.73 We consider below the way in which each of the above interference modes can most appropriately be characterised. In the process, we report on the measured performance of commercially available UTRA-FDD user equipment. Parameters derived from these measurements (as opposed to the minimum requirements specified by 3GPP) are used in our further analysis of terminal-to-terminal interference. We note that our earlier technical work reported in the Discussion Document focused on the saturation (or blocking) effect caused by an interferer at the 3rd adjacent 5 MHz channel. In our new analysis we consider the impact of interference due to linear and non-linear receiver behaviour, as well as due to saturation, caused by interferers from a number of adjacent channels. The analysis is based on the use of 5 MHz channel widths as the component size in the spectrum packaging arrangements; however, as commented on later, the implications of the analysis also apply for systems using larger channel widths.

Adjacent-channel interference ratio

5.74 According to information theory, the maximum data throughput per unit bandwidth achievable over a communications link is a logarithmic function of the signal-to-interference-plus-noise ratio (SINR) experienced at the receiver. Consequently, the SINR is the key parameter in defining the spectral efficiency of a radio link. The level of SINR at a receiver is, in turn, a function of the radiated powers and spatial geometries of the transmitters of wanted and unwanted signals, in addition to the radio propagation environment.

5.75 Where an interferer transmits at a frequency that lies outside the nominal pass-band of the wanted signal, the level of interference experienced is a function of a) the interferer's spectral leakage, as defined by its emission power spectral density, and b) the frequency response of the filtering at the receiver. These two effects can be characterised by the interferer's adjacent-channel leakage ratio (ACLR) and the receiver's adjacent-channel selectivity (ACS) respectively[76]. The combination of these two parameters, in the form of $(ACLR^{-1} + ACS^{-1})^{-1}$, represents the fraction of the received interferer power which is experienced as interference by the receiver,

and is referred to as the adjacent-channel interference ratio (ACIR)[75]. In other words, for a received interferer power P_x at frequency offset Δf from the wanted signal, and for an ACIR of $A(\Delta f)$, the experienced interference power is given by $P_I = P_x / A(\Delta f)$.

5.76 Table 3 indicates the ACIRs for a terminal-to-terminal link with the interferer transmitting in the 1st to 4th adjacent 5 MHz blocks with respect to the wanted signal. These are computed based on the ACLR required for compliance with the corner points of the SE42 terminal station emission BEM adopted for the 2.6 GHz band (see Section 6 and the Information Memorandum), and the measured filtering characteristics[90] (i.e. ACS) of commercially available UTRA-FDD user equipment in the 2.1 GHz band.

Table 3: Terminal-to-terminal ACIR, where the interfering terminal station just complies with SE42 BEMs when radiating at maximum in-block EIRP.

	nth adjacent block			
	n = 1	n = 2	n = 3	n = 4
ACLR (dB)	33	45	54	63
ACS (dB)	53	65	65	65
ACIR (dB)	33	45	53	61

5.77 The above ACIR values are applicable in circumstances where the interfering terminal station just complies with the BEM specifications when radiating at full power (i.e. an EIRP of 31 dBm). These ACIR values are dominated by the emission spectral leakage (ACLR) of the interferer.

5.78 However, we have developed separate ACIR values that apply when a terminal station radiates at less than full power. This is because spectral leakage typically reduces with respect to the in-block EIRP when a terminal station radiates at less than full power, thereby resulting in an improved ACLR, and consequently, improved ACIR. Measurements of commercially available UTRA-FDD user equipment in the 2.1 GHz band indicate that, for an EIRP of 20 dBm, the achieved ALCR is better than the minimum requirements specified in 3GPP TS 25.101 by around 8 dB at the 1st adjacent channel, by around 5 dB at the 2nd adjacent channel, and by more than 10 dB at greater frequency offsets. Table 3 shows the improved ACIR values that apply, based on equivalent improvements in ACLR with respect to the SE42 BEMs, when the terminal station radiates at less than full power.

Table 4: Terminal-to-terminal ACIR, where the interfering terminal station readily complies with SE42 BEMs when radiating at less than maximum in-block EIRP.

	nth adjacent block			
	n = 1	n = 2	n = 3	n = 4
ACLR (dB)	41	50	64	73
ACS (dB)	53	65	65	65
ACIR (dB)	40	50	61	64

5.79 The ACIRs values in Table 3 and Table 4 are used in our analysis of terminal-to-terminal interference when considering transmissions from standard blocks and restricted blocks respectively.

Third-order inter-modulation products

5.80 In addition to the effects discussed above, it is also possible for signals received at adjacent channels to result in interference through inter-modulation products caused by the non-linear behaviour of the receiver. Consider a wanted signal received in frequency block n_0. Then, third-order nonlinearities in the behaviour of the receiver would imply that two interferers received at frequency blocks $n_0+\Delta n$ and $n_0+2\Delta n$ can result in co-channel interference within frequency block n_0.

5.81 These so-called inter-modulation (IM) products can be a significant source of degradation in SINR when the receiver is exposed to multiple un-attenuated adjacent-channel interferers. For example, an FDD terminal station receiving in block #34 would be subject to third-order IM products caused by TDD terminal station interferers received in block pairs (#35, #36) and (#36, #38). Similarly, an FDD terminal station receiving in block #25 would be subject to third-order IM products originating from block pairs (#23, #24), (#21, #23), and others[91].

5.82 3GPP TS 25.101 specifies that the inter-modulation characteristics of an FDD terminal station receiver should be such that the reception of two interferers, each at a level of −46 dBm and at frequency offsets of 10 and 20 MHz from the wanted carrier, should at most result in a 3 dB desensitisation. Measurements commissioned by Ofcom suggest that commercially available UTRA-FDD user equipment in the 2.1 GHz band suffer from 3 dB desensitisation with interferers at power levels of −30 dBm. This latter result, which implies that actual terminals perform 16 dB better than the 3GPP minimum requirements, is used for the modelling of IM products in our analysis.

Receiver saturation (blocking)

5.83 Naturally, the components in a receiver chain are unable to deal with arbitrarily large signal levels. If the absolute values of the received adjacent-channel signals are beyond a certain threshold, the receiver will be overloaded or saturated. The performance of the receiver is difficult to model in such circumstances, and parameters (such as the ACIR) which model the normal operation of the receiver are no longer helpful in predicting the levels of interference experienced or the achievable throughputs. Our analysis assumes that the saturation of the receiver would result in a zero radio link throughput. This is a conservative assumption, as in practice it is unlikely that throughput would fall to zero in all cases.

5.84 3GPP TS 25.101 specifies that a UTRA-FDD terminal station receiver should be able to apply a linear ACS of 33 dB to a 1st adjacent-channel interferer received at a power level of up to −25 dBm. Measurements commissioned by Ofcom suggest that commercially available UTRA-FDD user equipment in the 2.1 GHz band perform much better than this and can apply an ACS of 33 dB when subjected to a 1st adjacent-channel interferer power of up to −10 dBm or greater[92], i.e. 15 dB better than the 3GPP minimum requirements. Measurements indicate that even greater interferer power levels can be supported at the 2nd and 3rd adjacent channels. A threshold of −10 dBm is used in our modelling of saturation effects; i.e. if the aggregate received power of the adjacent-channel interferers exceeds this threshold then the terminal station is assumed to suffer from saturation and the downlink throughput is assumed to drop to zero.

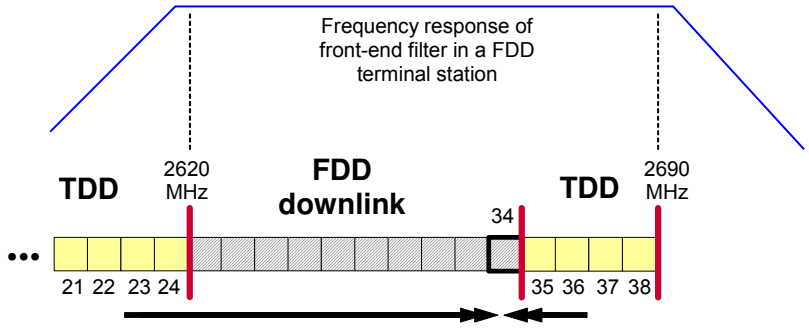
[91] Interferers at lower frequency blocks would be increasingly attenuated by the FDD terminal station's front-end (duplex) filter.

[92] Furthermore, measurements indicate that an ACS of around 53 dB applies when the power of the adjacent-channel interferer is −20 dBm.

Evaluation of terminal-to-terminal interference

5.85 In this part of Section 5 we summarise the results of our updated evaluation of the impact of interference caused by TDD terminal stations on the statistics of downlink throughput in an FDD cellular system. We consider the scenario where a TDD cellular network is deployed in the same geographical area as an FDD cellular network. We further assume that the TDD network operates within frequency blocks that are adjacent to those used by the FDD network in the downlink direction, thereby giving rise to the possibility of terminal-to-terminal interference. Figure 10 illustrates a specific award outcome and the sources of interference towards the paired (FDD) block #34 as examined in this study. We focus on block #34 since this is the FDD block that will be most susceptible to interference in this example. Note that this example corresponds to a total of 18 unpaired (TDD) blocks in the 2.6 GHz band.

Figure 10: Sources of terminal-to-terminal interference for the illustrative example of a specific award outcome. Arrows indicate direction of potential terminal-to-terminal interference into block #34



5.86 It should be pointed out that, in the context of terminal-to-terminal interference towards FDD mobile stations, there is a greater risk of IM products and saturation from adjacent-channel interferers received in blocks #25 to #38, than there is from those received in blocks #24 and below. This is because interferers received in blocks #25 to #38 fall within the pass-band of an FDD terminal station's front-end (duplex) filter, and would therefore not be attenuated prior to amplification and further processing. As shown in Figure 10, the pass-band of the front-end filter would nominally cover the frequency range 2620 MHz to 2690 MHz in order to allow the terminal station to receive signals from base stations transmitting in any of the paired (FDD) downlink blocks[93]. Interferers received in blocks #24 and below, however, would fall outside the filter's pass-band and would therefore be attenuated according to their frequency offsets from the pass-band edge. In the modelling of inter-modulation and blocking, we account for the roll-off of the front-end filter via attenuations of 0, 4, 8, and 12 dB at blocks #24, #23, #22, and #21 respectively.

5.87 The TDD system is modelled based on physical layer parameters that are similar to those of WiMAX[94]. Each TDD terminal station is scheduled for uplink transmission by

[93] While the use of tuneable front-end filters could in principle mitigate against adjacent-channel interferers in blocks #25 to #38, we do not envisage that such technologies can be cost-effectively incorporated within terminal stations in the near future.

[94] The TDD system is modelled with a nominal channel bandwidth of 4.1 MHz, uplink/downlink ratio of 1:3, frame duration of 5 ms, uplink sub-frame duration of 1.25 ms, scheduling interval of 20 ms, and adaptive modulation and coding (up to 64-QAM, ¾ rate coding) with power control. A throughput of 75% of the Shannon Limit is assumed over the radio link. It is assumed that VOIP and video conferencing services require throughputs of 30 kbits/s and 360 kbits/s respectively.

its serving base station and is allocated the appropriate frequency and time resource in accordance with the throughput required by the service and the throughput achievable on the radio link. The latter is a function of uplink EIRP, propagation path-loss and shadowing, and interference. The model includes uplink intra-system interference from a ring of adjacent TDD cells.

5.88 The FDD system is modelled based on physical layer parameters that are similar to those of UTRA-FDD HSDPA[95]. Here the metric of interest is the statistics of downlink throughput over the cell area as a result of an FDD terminal station receiving one packet per scheduling interval from its serving base station. The FDD downlink throughput is a function of downlink EIRP, propagation path-loss and shadowing, and interference. The model includes downlink intra-system interference from a ring of adjacent FDD cells.

5.89 The extended (urban) Hata model[96] is used to characterise mean path-loss over all radio links, assuming antenna heights of 30 and 1.5 metres for base stations and terminal stations respectively[97].

5.90 The impact of terminal-to-terminal interference on the FDD downlink is strongly dictated by the bursty natures of both TDD terminal station transmissions and FDD terminal station receptions. These effects are captured by a) modelling uplink scheduling of TDD packets, with those requiring least resources scheduled first, and b) assuming an FDD downlink packet arrival time that is uniformly distributed over the scheduling interval.

5.91 It should be pointed out that collisions between uplink TDD packets and an FDD downlink packet received at an FDD terminal station need not necessarily have a severe impact on the FDD downlink throughput. The effects of such collisions depend on the number of TDD transmitters, the amount of time-frequency resource utilised by each TDD packet transmission and their degrees of overlap (in time) with the FDD packet, the EIRP of the TDD terminal stations, and their spatial separations from the FDD terminal station.

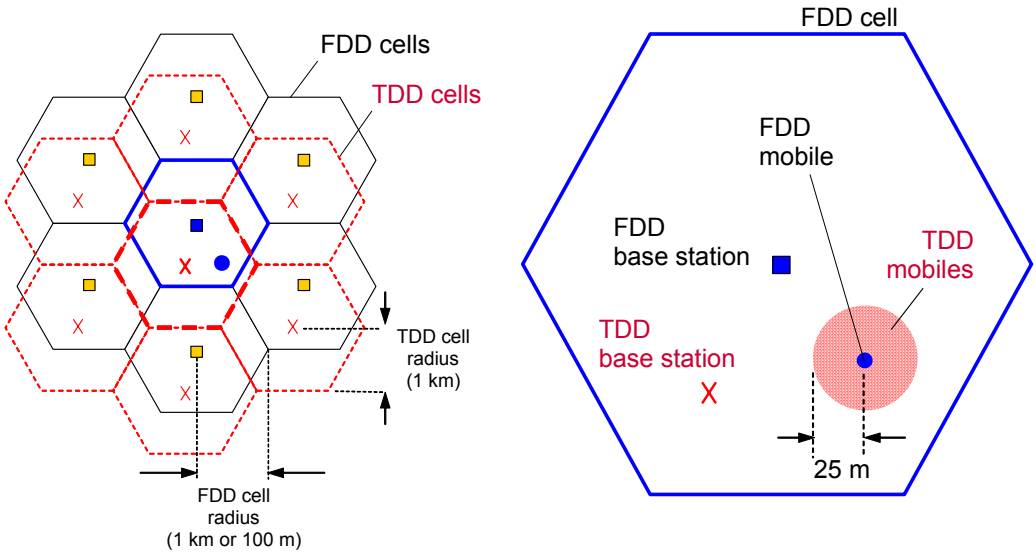
5.92 The above effects are captured via Monte Carlo simulations modelling the urban macro-cellular scenario depicted in Figure 11.

[95] The FDD system is modelled with a nominal channel bandwidth of 3.84 MHz, downlink packet duration of 2 ms, scheduling interval of 20 ms, and adaptive modulation and coding (up to 16-QAM, ¾ rate coding). A throughput of 75% of the Shannon Limit is assumed over the radio link.

[96] European Radiocommunications Office, "SEAMCAT user manual (Software version 2.1)," February 2004. See also Appendix-2.

[97] For all base-terminal links, shadowing standard deviations of 3.5 dB and 12 dB are assumed for separations of less than 40 metres and greater than 40 metres respectively. For terminal-to-terminal links, the propagation model corresponds to free-space path-loss (propagation exponent of 2) and a shadowing standard deviation of 3.5 dB. This represents line-of-sight propagation in large open areas.

Figure 11: Urban macro-cellular FDD scenario



5.93 In each Monte Carlo trial, the target FDD terminal station is randomly placed within the central FDD cell. A number of TDD terminal stations are then randomly distributed within a 25 metre radius of the FDD terminal station. Finally, the FDD terminal station (along with the surrounding TDD terminal stations) is randomly placed within a serving TDD cell. Note that this formulation corresponds to the case where the FDD terminal station is always in the proximity of a high density of TDD terminal stations (i.e. a TDD hot-spot). All terminal station locations are subject to a uniform probability density function. An FDD cell radius of 1 km is considered with maximum mean EIRPs of 61 dBm/(5 MHz) (antenna gain of 17 dBi) and 31 dBm/(5 MHz) (antenna gain of 0 dBi) for the FDD base stations and FDD terminal stations respectively.

5.94 In light of the findings of earlier work reported in the Discussion Document, we have focused our further analysis on hot-spot scenarios only. In the representative hot-spot scenario examined here, the number of TDD terminal stations simulated is derived by reference to an average spatial density of 1 person per square-metre. This figure is consistent with measurements commissioned by Ofcom of population densities observed in hot-spot locations such as cafes and conference centres. We then assume that 1 in 10 individuals, randomly selected within the hot-spot, will be using their wireless device at any Monte-Carlo snapshot. Note that this still corresponds to a substantial number of 196 terminal stations simultaneously operating (although not necessarily simultaneously transmitting) within a radius of 25 metres from a potential victim of terminal-to-terminal interference. For this scenario we make what we consider to be the reasonable assumptions that 50% of the population use wireless equipment operating in bands other than the 2.6 GHz band, and that, of those who do use the 2.6 GHz band, only 50% use TDD technology.

5.95 The above assumptions imply that the spatial density of TDD terminal stations operating in the 2.6 GHz band at any Monte-Carlo snapshot would be of the order of 1/40 per square-metre. Given the total of 18 unpaired (TDD) blocks in the band-plan example considered (see Figure 10), and assuming a uniform distribution of TDD terminals across the blocks, the above corresponds to a density of 1/720 per square-metre per 5 MHz TDD block.

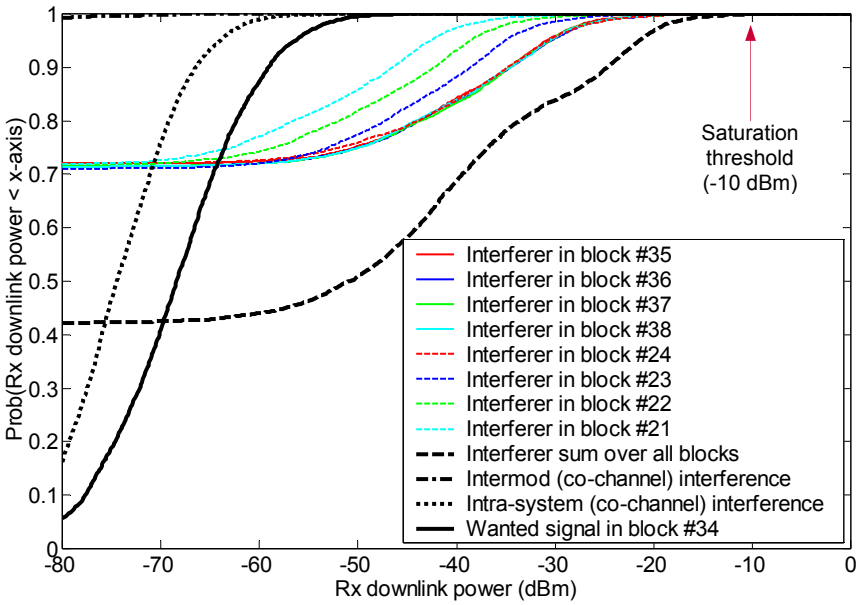
5.96 We first consider the situation where the TDD hot-spot is served by macro-cells supporting services in blocks #35[98] to #38, and #21 to #24. A TDD cell radius of 1 km is considered, with a TDD base station receive antenna gain of 17 dBi, and a TDD terminal station maximum mean EIRP of 31 dBm/(5 MHz).

5.97 Figure 12 shows the resulting cumulative probability distributions of the signal powers present at the output of the front-end filter of an FDD terminal station over the time interval in which an FDD downlink packet is received in block #34. As noted earlier, the adjacent-channel transmissions by TDD mobile stations in blocks #35 to #38 fall within the pass-band of the FDD mobile station's front-end filter, and so are un-attenuated (thin solid lines). In comparison, the adjacent-channel transmissions by TDD mobile stations in blocks #21 to #24 fall outside the pass-band of the FDD terminal station's front-end filter, and so are attenuated in accordance with their respective frequency offsets from the pass-band edge (thin dashed lines). The thick dashed line corresponds to the aggregate (sum) of the received adjacent-channel interferer powers from TDD terminal station transmissions in blocks #21 to #24, and #34 to #38[99]. As can be seen, while the aggregate interferer power exceeds −25 dBm with a probability of around 10%, it does not exceed the −10 dBm saturation threshold of commercially available 3G user equipment. This implies that the probability of blocking is very low, even in hot-spot situations, and is likely to be even less of a problem than was indicated in the Discussion Document.

[98] Note that block #35 itself will be a restricted block for base station use as discussed earlier in this section. However, in order to help illustrate the interference effects we assume, hypothetically, that it could be use for macro cells. The implications of making block #35 a restricted block are considered later.

[99] Note that it is the aggregate (sum) of the received adjacent-channel interferer powers from TDD terminal station transmissions which is relevant when considering the potential for saturation to occur. As can be seen, this total unwanted received power (thick dashed line in Figure 12) is significantly greater than the wanted received power in block #34 (thick solid line in Figure 12). However, the FDD terminal receiver will be tuned to block #34 and, provided it has not been saturated, will discriminate between the wanted and unwanted signals by suppressing the adjacent channel interferers through various stages of (intermediate-frequency and baseband) channel filtering.

Figure 12: Cumulative probability distributions of signal powers received at an FDD terminal station operating in block #34, in an urban macro-cellular FDD scenario, and in the presence of adjacent-channel TDD macro-cells

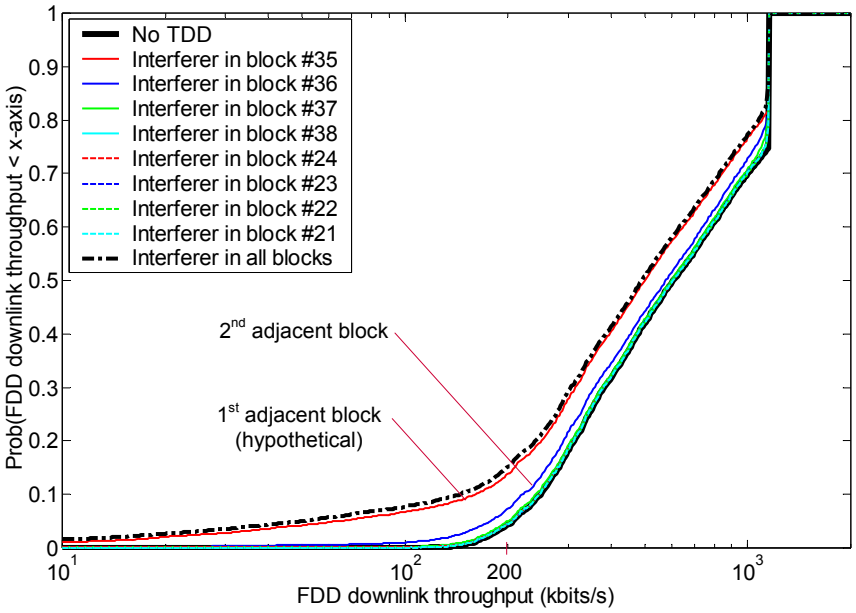


5.98 The impact of the adjacent-channel interferers on the FDD downlink throughput is shown in Figure 13, again expressed in the form of cumulative probability distributions. The throughput distributions are shown both in the absence and presence of interference from TDD terminal station transmissions in adjacent blocks #35 to #38, and in blocks #21 to #24. Note that the throughputs correspond to a single 2 ms packet received over a 20 ms scheduling interval. The ACIR values in Table 3 are used....

5.99 Note that the simulation results are not particularly sensitive to the throughputs required by the TDD services[100]. This is because, while a TDD mobile station which supports a high-rate service would require a greater fraction of the uplink radio resource, fewer such mobiles can be scheduled within a cell. The net effect is that aggregate interference generated remains broadly unchanged.

[100] TDD mobile stations are assumed to be accessing a VOIP service which requires a throughput of 30 kbits/s within a 20 ms scheduling interval.

Figure 13: Cumulative probability distributions of FDD downlink throughput in block #34, in an urban macro-cellular FDD scenario, and in the presence of adjacent-channel TDD macro-cells.



5.100 Figure 13 shows that, in the absence of interference from TDD terminal stations (thick solid curve), there is a 5% probability that the FDD downlink throughput drops below 205 kbits/s over the cell area. However, when in the proximity of TDD terminal stations transmitting in all the simulated adjacent blocks (thick dashed line), there is a 5% probability that the throughput drops below 55 kbits/s over the cell area.

5.101 An important point to note is that TDD terminal station transmissions in the 1st adjacent block, #35, contribute virtually all of the aggregate interference experienced by the FDD terminal station from TDD terminals (i.e. the additional impact of blocks #36 to #38 and #21 to #24 is negligible). When in the proximity of TDD terminal stations transmitting in the 2nd adjacent block #36 (but not the 1st adjacent block #35), there is a 5% probability that the throughput drops below 180 kbits/s over the cell area.

5.102 Based on the above results, we can draw the following conclusions.

i) TDD terminal stations operating in the 2nd adjacent block (and beyond) with respect to an FDD terminal station cause little degradation in the FDD downlink throughput. The ACIR of 45 dB at the 2nd adjacent block is sufficient to mitigate the impact of terminal-to-terminal interference.

ii) TDD terminal stations operating in the 1st adjacent block with respect to an FDD terminal station can cause a significant (albeit graceful) degradation in throughput. The ACIR of only 33 dB at the 1st adjacent block is not sufficient to mitigate the impact of terminal-to-terminal adjacent-channel interference in the challenging geometries examined. However, this assumes that the 1st adjacent block is used for macro-cells, a point which we pick up below. But even so, this scenario would not represent a step change in performance experienced by FDD users.

iii) In principle, saturation of the FDD terminal station receiver can result in a severe (i.e. non-graceful) degradation in FDD downlink throughput. However, even in the challenging geometries investigated, the total received adjacent-channel interferer power is well below the −10 dBm threshold (see Figure 12) supported by 2.1 GHz UTRA-FDD user equipment commercially available today. This means that FDD terminal stations in the 2.6 GHz band, with receiver characteristics identical to (or better than) those that are available today in other bands, would be able to operate in the presence of TDD terminal stations without suffering from saturation. Consequently, one may conclude that saturation (or blocking) is not a material cause of throughput degradation in the context of terminal-to-terminal interference[101].

iv) Third-order inter-modulation products were found to cause little degradation in downlink throughput in the scenarios investigated. This is because the received powers of any two adjacent-channel interferers rarely jointly exceed the threshold of −30 dBm (see Figure 12) supported by 2.1 GHz UTRA-FDD user equipment commercially available today.

5.103 Once again, we point out that the results apply to a scenario where a high-density of interfering TDD terminal stations is always present within a 25 metre radius of the FDD terminal station. This is clearly not always (or often) the case in practice, but the scenario is indicative of FDD downlink performance in the vicinity of TDD hot-spots.

5.104 Points i) and ii) above suggest that it is only the 1st adjacent-block terminal-to-terminal interference that could, hypothetically, be an issue in urban macro-cellular deployments.

5.105 In practice, of course, the unpaired (TDD) blocks immediately adjacent to paired (FDD) downlink blocks will be subject to restrictions on the base station in-block EIRP levels for the reasons discussed earlier in this section. Hence, it is likely that these restricted blocks could only be used for deployment of TDD pico-cells. Moreover, in those situations where high densities of users are anticipated (e.g. conference centres, train stations, etc.) it is likely that operators of TDD networks would in any case want to deploy pico-cells in order to adequately satisfy the demands for throughput.

5.106 We have therefore taken the analysis further to examine the impact of interference caused by TDD pico-cellular deployments in restricted blocks where the TDD base stations are subject to a maximum in-block mean EIRP of 25 dBm/(5 MHz)[102]. Figure 14 and Figure 15 show the impact of TDD interference in this case, for a TDD cell radius of 100 metres. A TDD terminal station maximum in-block mean EIRP of 25 dBm/(5 MHz) is assumed in order to match that of the serving TDD base station. The ACIR values of Table 4 are also assumed here, corresponding to the higher ACLR

[101] Note that even in the unlikely event that terminal-to-terminal saturation effects were to cause material degradations in downlink throughput, such degradations would be observed equally in all FDD downlink blocks. This is because terminal station receiver components that are most likely to be saturated as a result of adjacent-channel interferers are typically protected only by a front-end RF filter whose pass-band covers the whole of the FDD downlink spectrum. An important implication of this is that, so far as saturation is concerned, all FDD downlink blocks in the 2.6 GHz band would have a similar usability.

[102] For computational simplicity, the analysis assumes pico-cellular TDD deployment in all adjacent blocks. However, as shown earlier, the effects of the 2nd adjacent block (and beyond) are very small even for macro-cellular TDD deployments, and so the results are not distorted by this assumption.

values achieved by TDD terminal stations when transmitting below the maximum in-block mean EIRP of 31 dBm (e.g. when located within a pico-cell).

Figure 14: Cumulative probability distributions of signal powers received at an FDD terminal station operating in block #34, in an urban macro-cellular FDD scenario, and in the presence of TDD pico-cells

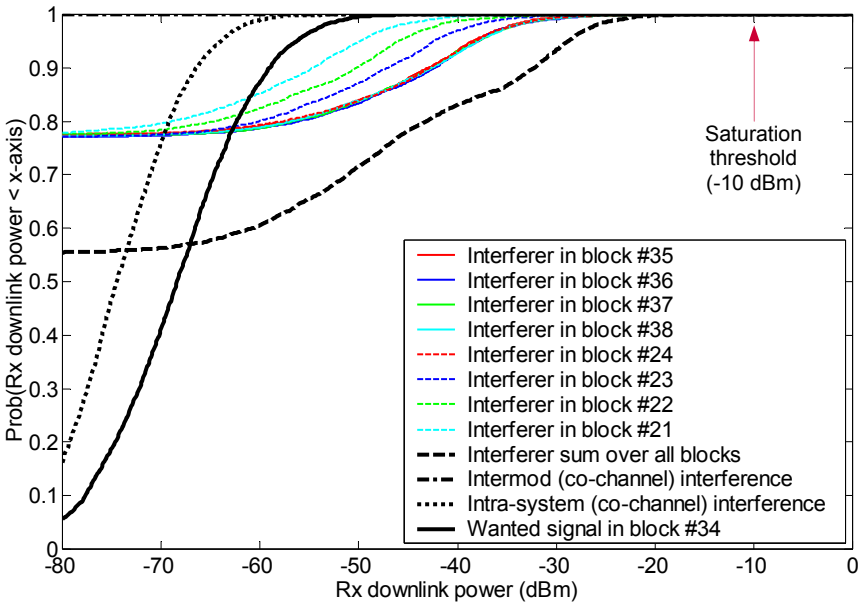
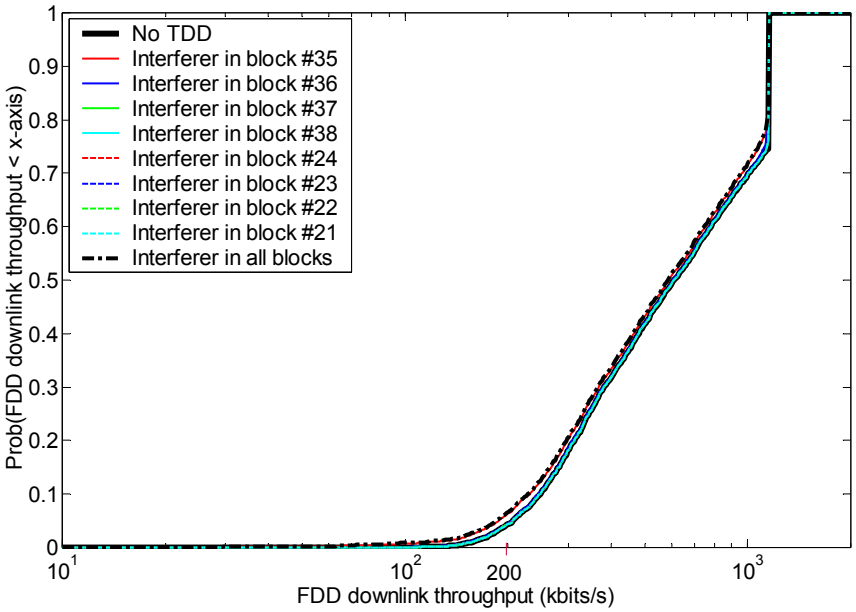


Figure 15: Cumulative probability distributions of FDD downlink throughput in block #34, in an urban macro-cellular FDD scenario, and in the presence of adjacent-channel TDD pico-cells



5.107 The results of Figure 15 clearly indicate that, when served by a TDD pico-cell, TDD terminal stations operating in a restricted 1st adjacent block with respect to an FDD terminal station cause little or no degradation in the FDD downlink throughput. There

are two reasons for this. The first reason is that, due to its proximity to a serving base station, a TDD terminal can use high-order modulation and coding to achieve the required throughput without the need to use high transmission powers and large proportions of the uplink time-frequency resource. Secondly, the ACLR of the TDD terminal station (and hence the ACIR) improves as a result of the reduced in-block radiation power that applies in a pico-cell, thereby helping to further mitigate the impact of interference at the FDD terminal station.

5.108 The results of this further analysis confirm the substance of the conclusions that we presented in the Discussion Document, namely that the effects of terminal-to-terminal interference are very modest. We have probed much further into the one area where there were residual concerns relating to hot-spot scenarios, and we have confirmed that the impact of interference is likely to be very limited even in these situations, particularly when taking account of measures such as the use of pico-cells. In carrying out this further analysis we have taken into account of interference experienced as a result of limited ACIR, inter-modulation products, and saturation effects, as requested by some respondents to the Discussion Document. Indeed, the results suggest that the chances of saturation (or blocking) are actually much smaller than even the earlier analysis had implied might be the case, and that the blocking effect is, in fact, smaller than that due to limited ACIR.

5.109 The main reasons why the further analysis indicates that the chances of blocking are even less than suggested in our earlier analysis are as follows.

a) The measurements of commercially available FDD user equipment indicate that these perform significantly better than the minimum requirements set out in the 3GPP Specifications (which are now over 10 years old).

b) We had used a simplified model in our previous work, whereby unwanted adjacent-channel signals received at a level above a pessimistic threshold value would automatically cause blocking of an FDD terminal station and result in a zero downlink throughput. We have now implemented a more realistic model, whereby the FDD terminal stations experience a more graceful degradation in performance (or drop in throughput) when adjacent-channel signal levels are below the threshold at which commercially available user equipment are found to suffer from blocking.

c) We have used more realistic models of both power control and uplink scheduling (i.e. bursty transmissions) for the TDD terminal stations. This also contributes to the reduced levels of interference experienced by FDD terminal stations. These are particularly noticeable in the case of TDD pico-cells which are likely to be deployed in locations where dense usage is anticipated.

5.110 Whilst this further analysis has focused on hot-spot scenarios, we can infer that the effects of interference in average density scenarios are also likely to be less than we had indicated in the Discussion Document.

5.111 Although we have not explicitly evaluated the impact of interference on the quality of specific wireless services, our analysis suggests that any degradation in the achievable downlink packet throughput would be at most marginal, and that the resulting quality of services would be broadly the same as that achievable in the absence of terminal-to-terminal adjacent-channel interference.

5.112 Throughout our quantitative analysis we have focussed on the case of interference from TDD terminal stations to FDD terminal stations. This is because those

responses which expressed concerns on terminal-to-terminal interference came from stakeholders who are interested in the use of the 2.6 GHz band for FDD applications. However, as noted in paragraph 5.18 at the start of this section, TDD terminal stations are similarly exposed to the effects of interference from terminal stations (and possibly more so given the number of blocks in which FDD and unsynchronised TDD terminals could transmit and which may fall within the front-end filter passband of TDD terminals). However, as noted in the Discussion Document, no stakeholders who have expressed interest in the use of the 2.6 GHz band for TDD applications have raised concerns about this type of interference.

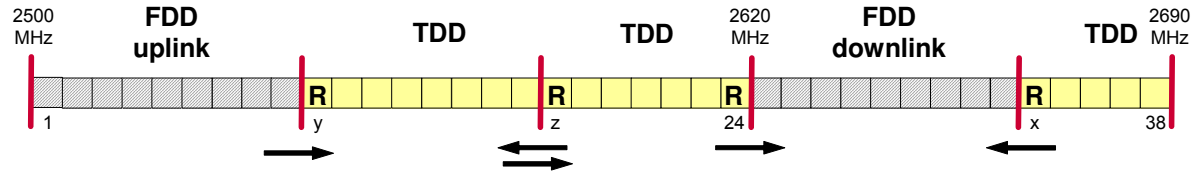
5.113 Finally, we note that the presented analysis was undertaken for the case of FDD and TDD technologies using nominal channel bandwidths of 5 MHz. However, the results would still broadly apply in the case of greater channel bandwidths. This is because we have accounted for interferers from multiple adjacent 5 MHz blocks in our analysis which, to a first order, will be equivalent to interferers from a smaller number of wider blocks.

Impact on adopted technical conditions and spectrum packaging

5.114 As explained earlier in this section, in order to adequately manage the risk of base-to-base interference, restricted 5 MHz blocks are applied at frequency boundaries which separate paired (FDD) and unpaired (TDD) spectrum, or at those which separate licensees of unpaired (TDD) spectrum.

5.115 For reference, the positions of the restricted blocks are repeated in Figure 16 below for the illustrative example of a specific award outcome. Although the restricted blocks are primarily intended to mitigate base-to-base interference, they also have important implications with respect to terminal-to-terminal interference, as discussed next.

Figure 16: Restricted blocks for the illustrative example of a specific award outcome. Arrows indicate direction of potential terminal-to-terminal interference. Restricted blocks are marked with "R"



5.116 Based on the results of the analysis outlined in the previous sub-section, we believe that there is a risk of significant 1st adjacent-block interference from TDD terminal stations towards FDD terminal stations, where the TDD terminal stations are served by high-power macro-cellular base stations, and where there is a high density of TDD terminal stations operating in the spatial vicinity of the FDD terminal stations. However, even in such challenging scenarios, the impact of interference from TDD terminal stations operating in the 2nd adjacent block (or beyond) is insignificant. With reference to Figure 16, the above implies that there is little risk of interference toward FDD terminal stations from TDD terminal stations which operate in standard blocks.

5.117 The results further indicate that there is little risk of adjacent-block interference from TDD terminal stations towards FDD terminal stations if the former are served by low-power pico-cellular base stations. This is consistent with the case of TDD terminal stations that operate in the restricted blocks immediately below and above the FDD

downlink spectrum (i.e. block #24 and block “x” in Figure 16). In other words, the restrictions on in-block EIRP imposed on TDD base stations in the aforementioned two restricted blocks remove the circumstances in which FDD terminal stations might suffer from interference caused by TDD terminal stations.

5.118 While in our analysis we specifically addressed the case of interference from TDD terminal stations to FDD terminal stations, the arguments and results also broadly apply in the opposite direction. This suggests that there is a risk of significant interference being experienced by TDD terminal stations operating in the restricted block above the FDD uplink band (i.e. block “y” in Figure 16) due to FDD terminal transmissions in the 1st adjacent block.

5.119 Extrapolating the results to the case of interference between unsynchronised TDD terminal stations, one may similarly conclude that the restricted blocks at the frequencies separating licensees of unpaired (TDD) spectrum (e.g. block “z” in Figure 16) effectively mitigate the impact of terminal-to-terminal interference toward TDD terminal stations in standard blocks, while TDD terminal stations in the restricted blocks are likely to suffer from terminal-to-terminal interference. It should be noted that here the licensees have the additional option of synchronising their uplink and downlink phases in order to effectively eliminate the possibility of terminal-to-terminal interference.

5.120 On the basis of the above analysis it is clear that the mitigation of terminal-to-terminal interference in standard blocks is already accommodated in the spectrum packaging illustrated in Figure 9 by the requirements imposed to manage base-to-base interference. Consequently, no modification to the defined technical conditions or spectrum packaging is necessary to deal with additional terminal-to-terminal interference.

5.121 It is also important to note that, on the basis of the adopted technical conditions and spectrum packaging, the restricted blocks are not protected from terminal-to-terminal interference to the same extent as standard blocks. In other words, the usability of restricted blocks is defined by their limited protection from terminal-to-terminal interference as well as by the restrictions on base stations transmission rights.

5.122 The technical conditions adopted by Ofcom in relation to use of the 2.6 GHz band by terminal stations are in line with those developed by the SE42 project team and are briefly discussed below (see Section 6 and the Information Memorandum for further details).

i) A terminal station in-block mean total radiated power (TRP) of 31 dBm/(5 MHz) will apply for all frequency blocks. For omni-directional transmissions, the specified TRP is equivalent to a mean EIRP of 31 dBm/(5 MHz), but allows the possibility of increased EIRP in specific directions subject to appropriate reductions of EIRP in other directions.

ii) All terminal station types will be subject to a single BEM profile, as detailed in Section 6 of this document and the Information Memorandum. This BEM is derived from the 3GPP TS 25.101 user equipment spectrum emission mask (relative) requirements based on a transmission power of 30 dBm/(3.84 MHz).

Stakeholder responses on terminal-to-terminal interference within the 2.6 GHz band and Ofcom's views on the issues raised

5.123 In the following paragraphs we present a detailed review of stakeholder responses to the Discussion Document of August 2007 which relate to the issue of terminal-to-terminal interference. For each topic, we cite statements from various stakeholders, followed by a clarification of Ofcom's views on the issues raised.

5.124 There was a considerable amount of feedback from stakeholders on the question of Ofcom's assessment of the terminal-to-terminal blocking effect. While some stakeholders agreed with Ofcom's analysis, others argued that Ofcom has under-estimated the impact of interference. The feedback covered a range of issues relating to Ofcom's analysis, including the adopted methodology, the modelling of wireless services, assumptions on geometries and user densities, and proposed mitigation techniques.

5.125 Qualcomm commented that: "UE blocking is not the limiting factor in terms of minimum centre to centre frequency separation" and that: "The limiting factor in terms of minimum centre to centre frequency separation is the out-of-band / spurious emissions from the TDD MSs interferer into the victim UMTS UE Rx band, which has not been studied by Ofcom in Annex 6".

- **Ofcom's view** – We agree that receiver saturation (sometimes referred to as blocking) is not the limiting factor in this instance, and that spectral leakage at the transmitter combined with the filtering response at the receiver are the critical parameters. This has been taken into account in our further analysis described above.

5.126 Two stakeholders questioned the assumption of a 15 MHz centre-to-centre frequency separation in Ofcom's terminal-to-terminal blocking analysis. One of them stated: "We question why 15 MHz is used when under the Ofcom proposals this frequency separation can be 10 MHz or even 5 MHz".

- **Ofcom's view** – The Discussion Document of August 2007 investigated the blocking issue at a 15 MHz offset, given that issues relating to the 1st adjacent-channel interference (5 MHz offset) had been addressed in the earlier December 2006 Consultation. However, we have addressed all frequency offsets in our further analysis described above.

5.127 Ericsson argued that: "Ofcom's assessment does not take any account of the increased quality of service demands of real time data services such as streamed video", and as such, "Ofcom's assessment of the blocking effect is significantly flawed". Ericsson also commented that: "Ofcom's assessment does not take into account the issue of the level to which users may be aware of blocking. For originating calls it will be clear that there is a problem and users may be able to attempt to move out of range of the blocking device, however for terminating calls, the user may not be aware that calls are failing". Taking a somewhat different view, BT stated that: "We would expect that the main use of the 2.6 GHz spectrum would be for packet-based transmission and would not expect the majority of the traffic to be used to provide time critical services such as VoIP. Packet-based services are expected to be more resilient to intermittent interference".

- **Ofcom's view** – We believe that evolutions in technology over the past decade firmly point towards the predominance of packet-switched (as opposed to circuit-switched) wireless systems. However, we also believe that such systems will

support a mix of real-time and non-real-time communications services. In our further analysis described above we have assessed the impact of terminal-to-terminal interference by computing the probability distribution of the FDD downlink packet throughput over a scheduling interval of 20 ms. The impact on the quality of different services (real-time or otherwise) can be inferred from such statistics and the presented analysis shows that a range of services can be supported with little degradation in the perceived quality of service.

5.128 Certain stakeholders commented on the issue of pico-cellular deployments. Qualcomm noted that: "Ofcom considers that blocking is most likely to occur when the victim handset is at the edge of its reception area and when the interferer is at maximum power which would not be the case in a micro or pico-cells deployment for UMTS or WiMax. While this assumption may be generally true, we believe that a quantitative analysis is required to address the specific WiMAX into UMTS interference scenario considered by Ofcom".

- **Ofcom's view** – The issue of pico-cellular deployments can best be addressed in the context of the adopted spectrum packaging. We have quantitatively demonstrated that there is a risk of 1st adjacent-channel terminal-to-terminal interference from TDD macro-cells to FDD macro-cells. This, however, is not an issue because the restricted blocks defined in the spectrum packaging mandate a minimum block-edge separation of 5 MHz between TDD macro-cells and FDD macro-cells. We have also quantitatively demonstrated that there is little risk of terminal-to-terminal 1st adjacent-channel interference from TDD pico-cells to FDD macro-cells. It is also evident that the risk of interference would be less (or at least, no greater) for FDD pico-cells. This is because it is highly likely that an FDD terminal would experience better signal quality (and have access to a greater proportion of the FDD downlink radio resource) in a pico-cell than it would in a macro-cell.

5.129 A number of stakeholders commented on issues relating to high user-density (hot-spot) scenarios. Nokia stated that: "In high density deployments (flats and office blocks) mixing TDD and FDD systems will result in high mean rejection rates and a poor quality of service for end users (notwithstanding building wall losses)". BT, on the other hand, commented that: "Ofcom has considered some very high user densities for the TDD hot spots. However, TDD cells used to provide high bandwidth services will become limited by capacity rather than coverage in the presence of high user densities".

- **Ofcom's view** – We have assumed a people density of 1 person per square-metre in our recent analysis. We acknowledge that this is a high value, but we believe it is appropriate for characterising typical high-density scenarios. We have also assumed free-space propagation between the terminal stations, which corresponds to scenarios involving outdoor open areas. We note that the risk of terminal-to-terminal interference would be lower than that reported in this document when the terminal stations are located indoors (typically characterised by a propagation exponent of 3 to 4 for separations beyond 5 metres). Finally, we have accounted for capacity-limited scenarios by explicitly modelling scheduling on the TDD uplink.

5.130 Certain stakeholders expressed concerns regarding the impact of terminal-to-terminal blocking, as evaluated by Ofcom, on network performance, one respondent noted that: "The analysis concludes that the potential blocking problem exists from TDD handsets to FDD handsets only at distances up to eight meters. However, this remains a very significant issue as eight meters between users is a very large area

for potential interference problems, considering that users are very often situated closer than eight meters to each other, especially in urban areas". Another respondent commented that: "Even if the figure of 8 metres were accepted, then this still has a large impact on an operator providing a high quality service to its customers. Further analysis backed up by practical measurements is required to provide further evidence on the impact of terminal-to-terminal blocking". Ericsson argued that Ofcom's study "takes no account of the fact that terminal devices move about and that calls are of certain duration. Ericsson believes that in real life situations, assuming any significant level of take-up of TDD services, the probability of an FDD device being less than eight metres from a blocking TDD device at some point during a call, is significantly higher than Ofcom's assessment".

- **Ofcom's view** – As we have described in this document, the impact of terminal-to-terminal interference is not only defined by the spatial separation between the interfering and interfered terminal stations, but is also substantially dependent on the bursty nature of transmissions by the interfering terminal station, and the amount of the uplink radio resource allocated to it by the serving base station. Our analysis suggests that, given the adopted technical conditions and spectrum packaging, the impact of terminal-to terminal interference on downlink throughput in standard blocks is not significant.

5.131 Several other stakeholders suggested that Ofcom's analysis over-estimated the impact of terminal-to-terminal interference. BT noted that "terminal-terminal interference is over-estimated since it is assumed that all terminals are located on the same floor" and that "at short ranges the ITU-R P.1411 is arguably a better model". BT also noted that: "The intermittent nature of WiMAX transmissions (depending on the service delivered) was not taken into account in the Discussion Document. Neither was the fact that UMTS and HSPA benefit from the forward error correction in the victim receiver, which would reduce the impact of potential interference".

- **Ofcom's view** – We acknowledge that terminal-to-terminal interference would be significantly reduced if the interfering and interfered terminal stations are on different floors (propagation loss through reinforced concrete floors can approach 20 dB). At short ranges, the ITU-R P.1411 model reduces to free-space path-loss, and as such, is consistent with the extended Hata models used in our further analysis described above. Finally, we have modelled both the intermittent nature of transmissions and the use of modulation and coding schemes in our recent analysis.

5.132 Some stakeholders expressed reservations with regards to the mitigation strategies proposed by Ofcom for dealing with the effects of blocking. Ericsson stated that: "The techniques proposed for mitigating of the effects of blocking, including the use of alternative methods of service provision by FDD operators in the event of blocking, are neither commercially nor technically viable". Qualcomm commented that: "The incorporation of tuneable filters into terminals as a means for mitigating the impact of blocking in FDD terminal stations is currently neither achievable nor cost efficient". Another respondent stated that: "UK handsets designed specifically to cope with the UK allocation would increase the costs of service provision for UK customers without removing the blocking risk for European FDD handsets either roaming into the UK or being bought by UK residents elsewhere. Furthermore such specific handsets would be excluded from roaming on some networks outside the UK".

- **Ofcom's view** – As demonstrated in this document, the technical conditions and spectrum packaging adopted by Ofcom for the 2.6 GHz band do not require UK-specific handsets. Nor do they mandate the incorporation of any form of

interference mitigating technologies in those handsets beyond what is currently present in commercially available equipment at 2.1 GHz.

5.133 A number of stakeholders commented on the option of half-duplex operation of non-FDD systems in the 2.6 GHz band. Qualcomm argued that: "These options would include the implementation of TDD technologies in a half duplex mode in an FDD channelling arrangement. Indeed, all major next generation wireless access networks standards, including LTE, UMB and WiMAX, include provisions for a half-duplex FDD (H-FDD) mode in addition to FDD, and TDD modes. An H-FDD terminal can reuse most of the architecture of a TDD terminal, resulting in a negligible cost difference compared to a TDD terminal. This means standards such as LTE or WiMAX can utilize either paired or unpaired spectrum of the harmonized European band plan with a common low-cost, duplexer-free platform for their TDD or H-FDD terminals. Base stations supporting H-FDD terminals can operate in full duplex mode, allowing full utilisation of paired spectrum, similar to an FDD system. We therefore believe that the argument put forward by Ofcom that more unpaired spectrum than is set forth in ECC Decision DEC(05)05 is required to level the playing field for non-FDD versions of next generation wireless access standards is not a sustainable argument".

- **Ofcom's view** – We fully appreciate the reasons why stakeholders wishing to operate FDD technologies in the 2.6 GHz band might prefer if TDD technologies were only allowed to operate in half-duplex mode when using frequency blocks outside the CEPT-defined duplex gap (2570-2620 MHz).

- However, our analysis indicates that the technical conditions and spectrum packaging adopted in the 2.6 GHz band effectively mitigate the risks terminal-to-terminal (and of base-to-base) interference at frequency boundaries that separate paired (FDD) blocks from unpaired (TDD) blocks. Consequently, we believe that it is not necessary to mandate that wireless technologies operate in either full- or half-duplex modes when using spectrum outside the duplex gap.

- We also note that half-duplex profiles for technologies such as WiMAX either do not currently exist, or are in an early stage of development. Accordingly, we consider that the introduction of a restriction with respect to WiMAX use to half-duplex profiles would not only be unnecessary but would also act as a constraint on short term WiMAX deployment outside of the central 50 MHz of the 2.6 GHz band. Finally, we believe that it is correct to allow the market to decide the level of future demand for half-duplex operation of various wireless technologies, as realised through the acquisition of the appropriate amount of paired spectrum in the 2.6 GHz band.

5.134 On the question of a potential reduction in terminal station in-block power to 18 dBm/MHz EIRP, the majority of respondents were in favour of such a reduction on the basis that it would mitigate the impact of terminal-to-terminal interference. Qualcomm, for example, stated that they: "agree with the proposal to reduce the in-band power of terminal station to be consistent with 3GPP Specifications for WCDMA Power Class 3 UE (24 dBm/3.84 MHz). The out-of-band emissions resulting from this approach allow a reduction in the interference from a TDD terminal to a nearby FDD terminal and vice versa". Only Ericsson and Samsung were not in favour of this reduction, although no strong arguments were presented to justify this position. Samsung stated that: "there is no meaningful benefit in a reduction in the terminal station power as a licence condition".

- **Ofcom's view** – In line with the proposals by the SE42 project team, we have decided to retain a maximum in-block mean EIRP limit of 31 dBm/(5 MHz) for

terminal stations. We do acknowledge that a reduction of the limit to 24 dBm/(5 MHz) would further reduce the impact of terminal-to-terminal interference. However, as demonstrated in this document, the risk of terminal-to-terminal interference can be adequately managed through the use of restricted blocks (as we have adopted) even for a terminal station maximum in-block mean EIRP of 31 dBm/(5 MHz).

5.135 Some stakeholders expressed concern with regards to the use of spectral density in specifying the in-block EIRP, and the impact on OFDM transmissions in systems based on LTE and WiMAX. One, for example, stated that: "Reducing the power spectral density will restrict operation when the terminal concentrates power in a specific sub-channel/resource block in order to boost the link budget. This will reduce cell coverage for low data rate services such as speech / emergency calls. [We] would therefore propose that the limit is specified in terms of total power of around 24 dBm for the full transmit bandwidth".

- **Ofcom's view** – We agree. In line with developments in SE42, in-block EIRPs will be specified in units of dBm measured over a nominal bandwidth of 5 MHz, specified as dBm/(5 MHz).

Conclusions

5.136 In this sub-section we first presented an overview of those characteristics of terminal stations that are relevant to the study of terminal-to-terminal interference in the 2.6 GHz band, namely limited ACIR, non-linear distortion, and saturation.

5.137 We then summarised the results of our further analysis on the impact of interference from TDD terminal stations to FDD terminal stations, and presented quantitative results on the impact of the said interference on the statistics of downlink throughput across an FDD cell.

5.138 We demonstrated that there is a risk of significant 1st adjacent-block interference from TDD terminal stations towards FDD terminal stations, only in the hypothetical circumstances where the TDD terminal stations are served by macro-cellular base stations. However, the restrictions on base station emissions in the 1st adjacent TDD block will mean that it can not be used for macro-cell deployments. Meanwhile, our analysis shows that there is little risk of 1st adjacent-block interference from TDD terminal stations towards FDD terminal stations if the former are served by pico-cellular base stations. In all cases, the impact of terminal-to-terminal interference from the 2nd adjacent-block or beyond (i.e. greater frequency offsets) was shown to be insignificant. These results also broadly apply to the cases of interference from FDD terminal stations to TDD terminal stations, and to cases of interference between TDD terminal stations.

5.139 We have shown that the adoption of restricted blocks in the spectrum packaging – which is required to mitigate base-to-base interference at the relevant frequency boundaries – also provides the means for mitigation of terminal-to-terminal interference towards standard blocks. One implication of these results is that standard blocks within a given category (i.e. paired or unpaired) should not have a different utility on account of the potential for terminal-to-terminal interference.

5.140 Moreover, the potential for terminal-to-terminal interference will not require terminals that are specific to the UK in cases where the award leads to a band-plan that is different from the CEPT band-plan in ECC Decision (05)05.

5.141 We finally reviewed the concerns of stakeholders with regards to Ofcom's assessment of terminal-to-terminal interference in the 2.6 GHz band, and explained how these have been addressed in our latest analysis.

Coexistence with uses in spectrum adjacent to the 2.6 GHz band

5.142 In this part of the section we set out our analysis and decisions regarding coexistence of uses in the 2.6 GHz with uses in neighbouring spectrum bands. We consider the potential impact on the 2.6 GHz band from adjacent uses of the spectrum and the potential impact on these adjacent uses from future use of the 2.6 GHz band following the award. We cover the following adjacencies and uses.

a) Adjacent uses – 2500 MHz boundary

- Programme making and special events (PMSE) (2390 to 2500 MHz)
- Mobile satellite - Globalstar (2483.5 to 2500 MHz)
- Wideband data transmission systems and short range devices (2400 to 2483.5 MHz)

b) Adjacent uses – 2690 MHz boundary

- Civil and military radars (2700 to 3100 MHz)
- Earth exploration-satellite service (2690 to 2700 MHz)
- Radio astronomy (2690 to 2700 MHz)
- Space research (2690 to 2700 MHz)

5.143 In reaching our decisions we consider points made in responses to the December 2006 Consultation and the August 2007 Discussion Document[103].

Programme making and special events in the band 2390 to 2500 MHz

5.144 Programme making and special events (PMSE) use for video applications is adjacent to the 2.6 GHz band. PMSE users share the adjacent frequencies with licence-exempt applications such as WiFi in the range 2400 to 2483.5 MHz, and the mobile satellite service (MSS) in the range 2483.5 to 2500 MHz.

Summary of points raised in responses to the December 2006 Consultation and the August 2007 Discussion Document

5.145 A relatively small number of stakeholders responded on the potential for PMSE to receive interference from, or cause interference in, the 2.6 GHz and 2010 MHz bands[104]. Comments were also made on the ERA technical work carried out for the Discussion Document.[105] We received responses from the main PMSE users (including the BBC, ITN, JFMG and the Spectrum for Programme Makers Forum

[103] The Auction Rules Consultation did not address adjacency issues.
[104] As respondents tended to group their comments on the adjacency issues at both the 2500 MHz and 2025 MHz boundaries it is convenient to summarise these here. However, we discuss our assessment of the 2025 MHz adjacency later on in section 5 when dealing with the group of issues relating to the 2010 MHz band.
[105] The results of this work were contained in Annex 8 of the Discussion Document.

(SPMF)) and their concerns are set out below. Additionally, another stakeholder suggested that the burden for mitigating interference risks should be borne by incoming licensees rather than be placed on PMSE users.

5.146 The BBC, ITN, JFMG and SPMF were concerned about the potential level of interference on PMSE use from adjacent use in the 2.6 GHz and 2010 MHz bands and the impact this could have on the amount of spectrum which could practically be used for PMSE.[106]

5.147 These stakeholders suggested that the level of interference from use in the 2.6 GHz and 2010 MHz bands would be greater than that assessed by ERA in their technical analysis included in Annex 8 of the Discussion Document and that this could potentially lead to a reduction (as a result of impaired access to 2 channels out of a total of 18) in the UK's ability to:

- provide video coverage of emergency situations;
- win the right to host key cultural or sporting events through a lesser ability to provide quality coverage than other countries; and
- meet the commitments made to the International Olympic Committee with regard to access to spectrum.

5.148 To support this conclusion, the responses set out stakeholders' views that the technical analysis included in the Discussion Document underestimated the magnitude of adjacent channel interference and that the mitigating techniques which we suggested in paragraph 3.103 of the document were either not viable or already in use (the SPMF and JFMG responses give details on each of our suggested mitigating factors).

5.149 On the issue of the potential underestimation of adjacent channel interference, stakeholders commented that the technical analysis carried out by ERA was based on estimates of interference using simulated signals from a laboratory generator and that these would tend to generate much less interference than a real transmitter, in part because real transmitters are designed to just meet relevant spectrum masks in practice. Furthermore, ITN carried out a number of real-life tests and measurements at the adjacency with spectrum identified for 3G services (2.1 GHz) which suggested that interference from wireless services could cause loss of service for PMSE in the adjacent 10 MHz channel in real-life situations.

5.150 In light of the practical test results from ITN, the SPMF suggested the use of a 5 MHz guard band (with no use permitted in this guard band) at the 2025 MHz and 2500 MHz boundaries. JFMG also suggested the use of 5 MHz guard bands at the boundaries, combined with adjacent channel receiver filters, based on a simple free space path loss model. Under the JFMG proposal, the 5 MHz guard band at the 2500 MHz boundary would be at 2495 to 2500 MHz (i.e., below the 2.6 GHz band) and the guard band at the 2025 MHz boundary would be at 2020 to 2025 MHz (i.e., from within the 2010 MHz band).

[106] The responses considered this potential on spectrum available for PMSE use in conjunction with a number of ongoing policy developments including the award of the 2.6 GHz and 2010 MHz bands, our recent decision to grant a licence variation to UK Broadband (http://www.ofcom.org.uk/consult/condocs/bb_application/statement/) and the potential assignment of 3.4 to 3.6 GHz to IMT which was discussed at the ITU World Radio Conference in October and November 2007 (WRC-07).

5.151 None of the responses to the Discussion Document raised concerns over the potential of interference from PMSE into the 2.6 GHz and 2010 MHz bands.

Review of adjacency conditions

5.152 In the August 2007 Discussion Document, we set out our view that the risks of interference occurring (to PMSE) in practice is low and that, as a result, there was no need to impose any restrictions on uses either side of the 2500 MHz boundary.

5.153 Stakeholders who responded on this issue were concerned mainly with the potential for interference from base stations into PMSE use, although some did also question the scope for interference from the use of terminal stations. Ofcom still considers that transmissions from terminal stations are not a cause of concern requiring amendment the technical conditions. However, we accept that we may have underestimated the risk of adjacent channel interference from use of 2.6 GHz into PMSE in the extreme case of an award outcome where base station transmissions appear at the bottom of the band.

5.154 As we highlighted in paragraph 3.101 of the Discussion Document, base station transmissions could only occur in frequencies immediately adjacent to the 2500 MHz boundary if all lots in the 2.6 GHz band are awarded for unpaired use and that, even if this happened, the lowest 5 MHz would still be a restricted block.

5.155 However, to reduce the potential for adjacent channel interference from base station transmissions into PMSE receivers operating in channels adjacent to 2500 MHz, we have decided that it is desirable to place additional requirements on the level of out-of-band emissions that may be generated by base stations operating in the 2.6 GHz band from those proposed in the Discussion Document.

5.156 These additional requirements are consistent with the out-of-block requirements contained in CEPT Report 19 for base-station emissions operating within the 2.6 GHz band: we have extended these requirements to apply to frequencies below 2500 MHz.

5.157 Consequently we will require that base-stations operating within standard blocks in the 2.6 GHz band comply with a maximum mean EIRP emission level of -45 dBm/MHz within the 2470 to 2500 MHz band. This requirement represents a reduction of 49dB in the maximum base station out-of-band emission level from the +4 dBm/MHz requirement proposed in the Discussion Document. We consider that this reduction is justified in order to mitigate the impact of use of the 2.6 GHz band on adjacent PMSE services. We also believe that the new level is technically feasible at relatively low cost (as discussed earlier in relation to in-band issues) based on the same filtering requirements that other 2.6 GHz in-band adjacencies will require.

5.158 In a limited number of circumstances, a maximum mean EIRP emission level for base stations of -22 dBm/MHz within the 2470 to 2500 MHz band may also be permitted. This is to facilitate the operation of ‘low power’ base-stations and applies where there are restrictions on antenna placement. In order to make use of this alternative emission level, base-stations will need to comply with an maximum in-band power limit of 25 dBm/(5 MHz) together with a maximum height limit of 4m above ground level when antennas are located outdoors, or a maximum height limit of 10m above ground level when antennas are located indoors.

5.159 Annex 6 contains our revised analysis of the scope for interference into PMSE users, based on the modified base station out-of-band emission requirements outlined

above. The results are presented for two cases: with and without a channel filter at the PMSE receiver.

5.160 For the case where a channel filter is not used, the results estimate that, in the expected environment of operation, there remains some risk of interference to users operating in the PMSE channel adjacent to the 2500 MHz boundary (i.e., in the 2490 to 2500 MHz band). Minimum coupling loss separation distances of more than 100m are identified for some of the interference scenarios considered. However, this risk has been significantly reduced from that estimated within the analysis presented in the August 2007 Discussion Document.

5.161 For the case where a channel filter is used, the results indicate that, in the expected environment of operation, the risk of interference is reduced significantly. Minimum coupling loss separation distances are generally reduced to below 50 metres for many of the PMSE applications.

5.162 For the risk of interference to materialise a number of factors would need to be combined. These relate to whether the PMSE equipment used is operating at the limit of its receiver sensitivity, whether the PMSE equipment under consideration employs high gain antenna, whether the PMSE receive antenna is located at ground level or at roof-top level, whether a direct line of sight exists between the PMSE receive antenna and an adjacent channel interferer, and whether the frequency in use is adjacent to the 2500 MHz boundary.

5.163 Our assessment of the potential for interference also shows that the limiting factor in any interference to PMSE is dominated by the adjacent channel selectivity performance of the PMSE receiver. For example, the out-of-band emissions falling co-frequency into a PMSE receiver is estimated to be significantly lower (by tens of dBs) than that arising from poor receiver selectivity. In such circumstances interference can be further mitigated by PMSE users through the use of a channel or band filter at the receiver. A filter which improves the PMSE receiver adjacent channel selectivity performance by 40 dB will reduce the separation distances considerably to the point where we consider the probability of interference into PMSE to be low, as estimated in the results presented in Annex 6.

5.164 We also note that JFMG proposed in their response to the Discussion Document a revised PMSE channelling arrangement within the 2483.5 to 2500 MHz band. They indicate that within this 16.5 MHz range they are able to accommodate one 10 MHz PMSE channel. They therefore propose that the existing PMSE channel centred at 2495 MHz with 10 MHz bandwidth can be shifted down in frequency by 5 MHz to provide an additional 5 MHz guard band to the 2500 MHz boundary. The PMSE community through JFMG are free to implement this and, if they do, it will further reduce the probability of adjacent channel interference between PMSE users and users of the 2.6 GHz band.

5.165 We have considered the suggestion that the cost of any PMSE channel filters should be borne by incoming licensees rather than incurred by PMSE users. However, in taking into consideration the additional restrictions we are placing on out-of-band emissions from base-stations operating in the 2.6 GHz band, and the factors that need to be combined for any interference to occur, we consider that the risk of interference occurring to PMSE users in practice is particularly low. In addition, the circumstances of PMSE use are particular in that their use is shared with other users. We therefore do not think that it is appropriate to place the burden of the cost of channel filters on users in the 2.6 GHz band.

5.166 In summary, Ofcom considers that the technical arrangements adopted for the 2.6 GHz band provide adequate measures to manage the risk of interference to PMSE applications operating below 2500 MHz. For interference from PMSE into the 2.6 GHz award band, we are not proposing to place any further restrictions on the use of the 2390 to 2500 MHz band by PMSE users compared to the time of the publication of the December 2006 Consultation. The analysis we presented in that consultation continues to reflect the basis for our assessment of the interference potential from PMSE applications into the 2.6 GHz band.

Mobile satellite - Globalstar (2483.5 to 2500 MHz)

5.167 The Globalstar satellite system uses the 2483.5 to 2500 MHz band for mobile space to Earth communications between its spacecraft and its handheld terminals. The handheld terminals transmit to the spacecraft in the 1610 to 1626.5 MHz band.

5.168 Globalstar submitted a response to the Discussion Document which estimated the impact of services in the 2.6 GHz band on their mobile space to Earth communications operating in the adjacent 2483.5 to 2500 MHz band. Their analysis suggested that interference could occur to Globalstar handheld terminals as a result of out-of-band emissions from services in the 2.6 GHz band, even when assuming a conservative separation distance between Globalstar terminals and interferers (as Globalstar terminals will typically operate in rural areas). As such, Globalstar urged us to award the 2.6 GHz band in such a way as to minimise potential interference to its terminals.

5.169 In paragraph 5.28 of the December 2006 Consultation, we set out our view that the risks of interference occurring from terminals at the bottom of the 2.6 GHz band into Globalstar terminals is limited to a few tens of metres and that given the low density of Globalstar terminals this risk was sufficiently low as to not warrant any restriction on terminal use in the 2.6 GHz band.

5.170 In their analysis, Globalstar considered that there would be a possibility of interference from mobile handsets which might be a particular issue in rural areas. However, we consider that in these areas there is a very low probability of 2.6 GHz mobile terminals and Globalstar terminals being located in close proximity to each other and therefore it is appropriate to consider that a higher average distance between these devices will prevail. Given the low density of MSS handsets in service, there is no reason to change our view from that expressed in the December 2006 Consultation

5.171 As discussed above, in order to reduce the potential for interference to PMSE users operating in channels adjacent to the 2500 MHz boundary, Ofcom has decided that it is necessary to place additional restrictions on the maximum mean level of out-of-band emissions that may be generated by base-stations operating in the 2.6 GHz band compared to those specified within the Discussion Document. A consequence of this decision will be to reduce the potential for interference into Globalstar terminals.

5.172 Our updated analysis is set out in Annex 8 to this Statement, is based on the reduced base station out-of-band emission requirement and uses the same methodology Globalstar used in their response to the Discussion Document. The results show that the potential for interference is significantly reduced as a consequence of the adoption of the lower base-station emission requirements, to the extent that the risk of interference to Globalstar terminals may be considered to be negligible.

5.173 In preparing our analysis of interference, we used a conservative value for the permissible interference to Globalstar terminals. This value is based on the assumption of a 0.1 dB degradation to the Globalstar link budget. In practice, Globalstar terminals may well be able to tolerate higher levels of adjacent channel interference depending on the available margin at a mobile which will further minimise the likelihood of interference occurring in practice.

5.174 In summary we consider that the technical arrangements adopted for the 2.6 GHz band provide adequate measures to manage the risk of interference to Globalstar terminals operating below 2500 MHz from both base stations and terminal stations operating above 2500 MHz.

Wideband data transmission systems and short range devices (2400 to 2483.5 MHz)

5.175 In paragraph 5.25 of the December 2006 Consultation, we set out our view that the risks of interference between short range devices including Wireless Local Area Networks (WLAN) and uses above 2500 MHz would not pose a significant threat. No respondent provided any analysis supporting a different conclusion and our view on this has not changed.

5.176 The band 2400 to 2483.5 MHz is used for wideband data transmission systems including Wireless Local Area Network (WLAN) based on the IEEE 802.11 and 802.15 standards (which include WiFi and Bluetooth). The maximum EIRP for wideband data transmission systems is 20 dBm. They are separated from the bottom edge of the 2.6 GHz band by 16.5 MHz. Due to their low transmission powers and wide frequency separation from the 2500 MHz boundary, we do not expect that their use will cause any significant interference into the 2.6 GHz band. Also, due to the wide frequency separation, it is very unlikely that use in the 2.6 GHz band will be a significant source of interference to these short range devices.

5.177 Additionally, the 2400 to 2483.5 MHz band is used in the UK for licence-exempt short range devices operating to ERC Recommendation T/R 70-03 on a non-protected and non-interference basis. The interference assessment for wideband data transmission systems is also relevant for short range devices because the minimum frequency separation is the same (i.e. 16.5 MHz).

Civil and military radars (2700 to 3100 MHz)

5.178 Most large civil airports and military airfields in the UK are equipped with ground-based air traffic control (ATC) radars used for aeronautical surveillance operating within the 2700 to 3100 MHz band. Such radars provide the main radar coverage around airfields.

5.179 In the December 2006 Consultation we set out information on the use of the 2700 – 3100 MHz band for aeronautical radionavigation and the conclusions for our analysis of the potential interference impact. The conclusions were that, for the three types of radars analysed (Magnetron, Travelling Wave Tube and Solid State), 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 and 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. We did note that forward error correction techniques may find it more difficult to cope with the longer pulse widths of solid state radars.

5.180 Several stakeholders commented on the analysis of radar interference in their responses to the December 2006 Consultation.

5.181 One respondent commented that it seemed surprising that Ofcom had concluded that the potential for interference "seems unlikely to be significant", given Ofcom's analysis that it is the newer, solid state radar systems that may cause service degradation in channels towards the top end of the band and Ofcom's expectation that solid state technology would become more common. The BBC commented that it believed that the interference potential of air traffic control radars operating at 2.7 to 3.1 GHz into the award band was understated. It indicated that the top channels of the 2.6 GHz band are avoided by PMSE in locations where radar interference is likely and stated that technologies other than PMSE would need to be immune to the pulsed interference from radars.

5.182 Another stakeholder suggested that further study was necessary, in particular the interaction between the intermittent 'bursty' bit errors arising from radar interference and the closed loop retransmission and adaptive modulation and coding mechanisms of packet based communication systems. A different respondent was concerned about interference from radars and believed that further work was required to quantify the impact of radars on the 2500 to 2690 MHz band. GSA commented that relatively high uncertainty exists regarding the impact coming from aeronautical radar.

5.183 BT commented that the individual characteristics of different radar platforms can have very different impacts on radio and wireless systems, and asked Ofcom to expand the information on radar systems to allow evaluation of the potential impact on different types of wireless systems. Specifically, BT requested that Ofcom provide information on the operating frequencies and locations of the civil radars operating above 2700 MHz and the latest available information on the usage of the band by MOD radars. Intellect also commented on the need to make all technical information on adjacent services available.

5.184 In response to these comments we commissioned a study by ERA Technology Ltd to estimate the effect that adjacent channel interference from different types of radar systems may have on candidate mobile systems[107]. This study, the results of which we refer to below, indicated that radar systems should not be a cause of significant interference into use of the 2.6 GHz band. We also provided further details on the consideration of potential interference caused by military air traffic control and air defence radar systems. However, we were unable to publish any detailed information on the characteristics of individual civil or military radar systems as radar users consider the information sensitive and confidential.

5.185 Few stakeholders commented on the updated analysis of the potential interference from radars operating in 2700 to 2900 MHz contained in paragraphs 3.107–3.133 of the Discussion Document.

5.186 A stakeholder restated its concerns, commenting that, depending on the final results of the ERA study, and taking account of the combination of military usage and civil radar usage, our conclusion from the December 2006 Consultation that the potential for interference seemed unlikely to be significant should be reassessed.

5.187 NATS (National Air Traffic Services) wished to understand what consideration we had given to the effect of emissions from the 2.6 GHz band into radar systems and

[107] See http://www.ofcom.org.uk/consult/condocs/2ghzdiscuss/report.pdf.

what safeguards would be put in place to ensure that such emissions do not have a detrimental effect on the safe operation of radar above 2.7 GHz. NATS also requested clarification as to the role of aviation system operators formerly involved in Radio Site Clearance (RCS) processes following the closure of the National Frequency Assignment Panel (NFAP), and how this related to the 2.6 GHz band (and others).

Review of adjacency conditions

5.188 In light of NATS' response, we have reviewed the scope for interference into radar systems from use of the 2.6 GHz band as well as the potential impact of interference from radar systems into use of the 2.6 GHz band. We consider these in turn below.

5.189 We have reviewed the technical conditions related to emissions from the 2.6 GHz band falling into the aeronautical and radiolocation radar band at 2.7 to 3.1 GHz. In order to manage the potential risk of interference into radars, we have decided that it is necessary to reduce the level of out-of-band emissions that may be generated by base-stations operating in the 2.6 GHz band from that specified within the August 2006 Discussion Document.

5.190 Consequently we will require that base-stations operating within the 2.6 GHz band comply with a maximum mean EIRP emission level of -45 dBm/MHz within the 2700 to 2720 MHz band. This requirement represents a reduction of 49 dB in the maximum base station out-of-band emission level from the +4 dBm/MHz requirement proposed within the Discussion Document. We consider that this reduction is justified in order to mitigate the potential impact of use of the 2.6 GHz band on adjacent radar services. We also believe that the new level only incurs modest additional filtering costs, as it is based on the same filtering requirements that other 2.6 GHz in-band adjacencies will require.

5.191 We have also defined the requirements on out-of-band emissions from the 2.6 GHz band up to a frequency of 2720 MHz. At frequency offsets further separated from 2720 MHz, the unwanted emissions are governed by spurious emission requirements. The R&TTE Directive provides the appropriate framework for such requirements and they are therefore not considered further in this Statement.

5.192 We note that the above requirements on the maximum out-of-band emissions are regulatory limits, and that in practice we expect emissions to be lower than the maximum authorised in adjacent spectrum, particularly for frequency offsets further separated from the 2700 MHz boundary, due to the combined effect of filter and out-of-band emission roll-off considerations.

5.193 Our analysis shows that under certain assumptions made about the performance (or absence) of front-end filtering for radars, emissions in the 2.6 GHz band could potentially cause a risk of signal compression at the radar front-end amplifier (also referred to as blocking). However, we are not aware of any indication that this is likely to be a concern in practice. There appears to be no such impairment resulting in practice from existing PMSE use of the 2.6 GHz band. We are not aware of any concerns being raised in other countries on the issue of existing services operating in the 2.6 GHz band causing adjacent channel interference or blocking to radars. Respondents to our consultations have also not expressed any significant concern about this point or provided any analysis suggesting that there may be an issue.

5.194 Furthermore, the 2.6 GHz band has been identified internationally for terrestrial mobile use since the year 2000 and the 2700 to 2900 MHz band is used extensively

for radar in a number of European countries. We note that if the potential for blocking was a concern in practice, then it would be possible for radar operators to remedy the situation by improving the selectivity of radars so that they do not receive signal transmissions originating from adjacent bands.

5.195 We note that there are planning tools available to radar operators that relate to the siting of base stations. We received in 2006 the following information from the Department for Communities and Local Government on the planning approval process for telecommunications masts in the context of our assessment of the Radio Site Clearance process.

> "When operators submit a prior approval application they must submit evidence that the Civil Aviation Authority, the Secretary of State for Defence, or the aerodrome operator (as appropriate) has been notified of the proposal where it consists of the installation of a mast within 3 kilometres of the perimeter of an aerodrome" (see paragraph 50, page 17 and Annex 1, paragraph 6, page 31 of Planning and Policy Guidance on planning for telecommunications development, including radio masts and towers (PPG-8)[108]).

5.196 In addition, the Department of Transport have a planning circular which sets out guidance on safeguarding of civil aerodromes and technical sites, in order to ensure that their operation and development are not inhibited by buildings, structures, erections or works which infringe protected surfaces or have the potential to impair the performance of telecommunication systems[109].

5.197 This circular sets out the process whereby the MOD or the CAA may 'safeguard' an aerodrome, technical site and military explosive storage area by issuing maps to the local planning authority highlighting a particular area. When a planning application comes in for a development within the highlighted area on the map (and in some cases above specified height limits) the planning authority must send a copy of the application to the CAA or MOD, thus giving them the opportunity to comment on the development.

5.198 The planning process therefore provides a safeguard where masts are erected near an airfield that would allow then to consider any potential impact on radar operation as part of this process and take action as appropriate. For this reason we do not see the need for any additional measures designed to protect aeronautical radars.

5.199 However, in light of the particular nature of aeronautical services, we are giving the issue further consideration and if necessary we will update our view by the time of the award. If further analysis shows that the risk of interference to aeronautical radars requires specific further provisions, we anticipate that the cost of any such provisions would be for radar operators to bear (whether these relate to technical work needed to adjust the sensitivity of radar equipment to transmissions in adjacent bands which are allocated to other uses, or whether they be transitional measures that may be appropriate for adjacent users to take temporarily within a coordination area).

5.200 Turning to the question of interference from radars to the 2.6 GHz band, we consider that the conclusions set out in the Discussion Document remain sound and we have not received any evidence from stakeholders to the contrary. As explained in the

[108] http://www.communities.gov.uk/publications/planningandbuilding/ppg8

[109] http://www.dft.gov.uk/pgr/aviation/safety/safeguarding/safeguardingaerodromestechni2988

Discussion Document, we commissioned a measurement study from ERA Technology Ltd to examine the effect that radar out-of-band (OOB) and spurious emissions may have on UMTS and WiMAX mobile receivers that may operate in the 2.6 GHz band. The main aim was to quantify how such systems operate in the presence of out-of-band interference from different types of radar transmitter technologies. A secondary aim was to conduct sample band occupancy measurements at a number of major UK civil airports each operating a different type of radar system. The results from this study are published on the Ofcom website[110].

5.201 The ERA results indicate that the effect of narrowband - high power radar out-of-band interference arising from the antenna swept main beam region is marginal on the overall bit error rate of modern communications systems. The results support the analysis presented in Ofcom's technical study[111] published alongside the December 2006 Consultation that the forward error correction (FEC) coding present in UMTS and WiMAX mobile receivers is likely to be able to recover from such impulsive type of interference. ERA found that the dominant mode of radar OOB interference is broad-band harmonics arising from the antenna side-lobe regions. This interference is at a lower power level compared to the main beam coupling but is generated continuously. They found that the impact of this interference mechanism also to be marginal on the overall bit error rate in this case as it is statistically of low probability.

5.202 For the reasons given above we have concluded that:

a) the revised technical arrangements adopted for the 2.6 GHz band, using tighter out of band limits extending up to 2720 MHz, should provide adequate measures to manage the risk of interference into radars, and that planning procedures provide further scope for protecting the operation of radars located in aerodromes and technical sites, as does the potential to retrofit filters if radar operators consider it appropriate;

b) interference from radars into the 2.6 GHz band should not cause a significant impairment as the empirical work we commissioned showed the impact on the overall bit error rate to be marginal; and

c) as a consequence, interference from radar emissions should not be a source of material differences in utility as between different frequency blocks within the 2.6 GHz band.

Earth exploration-satellite service (2690 to 2700 MHz)

5.203 The UKFAT indicates that this band is allocated to the Earth exploration-satellite service (EESS) on a primary basis as a passive service. We are not aware of any current or planned use within the UK. Given the absence of any significant use within the UK we consider that there is no need to place restrictions on transmissions from the 2.6 GHz band to protect EESS use in the UK.

Radio astronomy (2690 to 2700 MHz)

5.204 The UKFAT indicates that this band is allocated to the radio astronomy service on a primary basis as a passive service. We understand that there is no current use of this band in the UK by the radio astronomy community. Furthermore, we understand

[110] http://www.ofcom.org.uk/consult/condocs/2ghzdiscuss/report.pdf

[111] http://www.ofcom.org.uk/consult/condocs/2ghzawards/technicalassessment/assessment.pdf

this band is not a priority for the UK nor is there any future research projects planned at UK observatories. For these reasons, we consider that it is not necessary to place restrictions on transmissions from the 2.6 GHz band to protect radio astronomy in the UK.

Space research (2690 to 2700 MHz)

5.205 The UKFAT indicates that this band is allocated to the space research (passive) service on a primary basis. Within the UK there is no identified use of this allocation. Given the absence of any significant use, we consider that there is no need to place restrictions on transmissions from the 2.6 GHz band to protect passive space research use of the 2690 to 2700 MHz band in the UK.

International implications of 2.6 GHz use

5.206 In this part of section 5, we consider the potential implications for use of the 2.6 GHz band on account of international uses of the spectrum. We address the issue of satellite use following agreement on WRC agenda item 1.9 as well as the position on coordination with neighbouring countries (France and Ireland).

Allocations to mobile-satellite and broadcasting-satellite services in parts of 2500 to 2690 MHz and the impact of WRC-07 agenda item 1.9

5.207 The 2.6 GHz band has primary mobile satellite service allocations in 2500 to 2520 MHz (space to Earth) and 2670 to 2690 MHz (Earth to space) in the main frequency allocation table and references to Footnotes 5.403 and 5.420 of the Radio Regulations, which allow the band 2520 to 2535 MHz and 2655 to 2670 MHz to be used for the mobile satellite, except aeronautical mobile satellite, service for operation limited to within national boundaries, subject to agreement under Article 9.21 of the Radio Regulations and with the provisions of Article 9.11A also applying.

5.208 Some stakeholders drew attention, in their responses to the December 2006 Consultation Document, to the allocations to space services in parts of the 2.6 GHz band, nothing that these allocations were due for review under WRC-07 agenda item 1.9. At the time, it was recognised that the ITU-R Conference Preparation Meeting for WRC-07 had not made much progress on this issue and stated that the impact of interference from satellite systems on the use of the 2.6 GHz bands in the UK could not be quantified until after WRC-07.

5.209 WRC-07 agenda item 1.9 had the following scope: "*to review the technical, operational and regulatory provisions applicable to the use of the band 2 500-2 690 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*".

Outcome of WRC-07 agenda item 1.9 and implications for satellite use of 2500 to 2690 MHz

5.210 WRC-07 made a number of changes affecting the 2.6 GHz band. The following changes will come into effect on 1 January 2009:

- removal of the primary allocations to the mobile-satellite service from the Table of Allocations in 2500 to 2520 MHz and 2670 to 2690 MHz for Regions 1 and 2;

- removal for Regions 1 and 2 of the references to Footnotes 5.402 and 5.420, covering mobile-satellite service use of the bands 2520 to 2535 MHz and 2655 to 2670 MHz (subject to agreement under Article 9.21 and coordination under Article 9.11A), although the footnotes still appear for Region 3; and

- a change to Footnote 5.384A so that the IMT-2000 identification becomes an IMT identification.

5.211 Additionally, WRC-07 agreed reduced limits of power flux density (pfd) for emissions from satellite systems, which apply to any systems that had not been notified to the ITU Radiocommunication Bureau and brought into use by 14 November 2007. Ten satellites operated by China, India, Indonesia and the Middle East and listed in Resolution 903 (WRC 07) are permitted to operate at higher powers, up to the pfd limits that were in force before WRC-07.

5.212 WRC-07 introduced provisions to allow Japan and India to use the new pfd values as thresholds for coordination in an area of 1000 km around their territories for mobile-satellite systems, rather than hard limits. The previous coordination thresholds for this band in the Radio Regulations were removed but a further exception allows mobile-satellite systems operated by Japan or India to use the previous coordination thresholds if those systems were notified and brought into use by 14 November 2007.

5.213 We consider that these changes made under WRC-07 agenda item 1.9 fully address the concerns of potential interference to services in the UK from future satellite use of the 2.6 GHz band.

International co-ordination – Memoranda of Understanding with France & Ireland

5.214 In both the December 2006 Consultation and the August 2007 Discussion Document we noted that a number of transmitter assignments in the 2.6 GHz band already exist in Ireland and France and that, in certain cases, these transmitters may give rise to signal levels in the UK that could impact on the use of the available spectrum in certain areas of the UK. The Discussion Document set out details of sample measurements of received signals that we undertook and presented the results of further propagation analysis. This suggested that emissions from France and Ireland were hardly measurable when we undertook the sample measurements and the analysis provided an estimate of the areas in the UK where operators would likely need to coordinate in respect of French and Irish operators at 2.6 GHz, if they used standard base station equipment without mitigation. The criteria used for coordination were based on CEPT Recommendation 01-01.

5.215 In response to the August 2007 Discussion Document BT commented that it remained concerned about the progress on finalising the cross border co-ordination agreements with France and the Republic of Ireland and felt that these were critical agreements which have the potential to significantly impact on what is possible within the 2.6 GHz and 2010 MHz band. BT proposed a trigger level of 21dBµV/m for 10% of the time rather than 37dBµV/m for 50% of the time which was used for many of the simulations. O2 also commented that the establishment of MoUs with France and Ireland was important and urged us to do so in advance of the award.

5.216 Since the publication of the Discussion Document, we have held a number of meetings with the administrations of France and Ireland to consider the potential effects of interference between the UK and neighbour countries. Acting on behalf of

HM Government, we have agreed Memoranda of Understanding (MoUs) with the administrations of France and Ireland relating to cross-border coordination for the management of interference in the 2.6 GHz band. These MoU are published alongside this Statement in the Information Memorandum.

5.217 The main features of the MoUs are as follows:

a) Coordination trigger threshold of 21 dBμV/m in a 5 MHz bandwidth;

b) Propagation model Recommendation ITU-R P.1546

c) 10% of time;

d) 50% of locations;

e) Receiver height of 3 metres;

f) Details of MMDS transmitters in the Republic of Ireland;

g) Details of military infrastructure (point to point) relay links and radar in France.

5.218 We consider that these MoUs provide an adequate protection for future users of the 2.6 GHz band in the UK. The trigger level of 21dBμV/m applies across the 2.6 GHz band to provide adequate protection regardless of the actual use of frequencies for uplink or downlink. It may be possible to revise this trigger level once the band has been awarded for new use in both the UK and Ireland or France respectively to take into account actual use. However, the MoUs provide a mechanism for operators to agree alternative arrangements bilaterally and this is may be a better mechanism for agreeing such changes than amending the MoUs themselves.

Implication of the overall interference environment for the utility of different frequencies in the 2.6 GHz band

5.219 One of the key issues in packaging the 2.6 GHz spectrum for award is whether blocks at different frequencies are of sufficiently similar utility to allow the auction design to be based on the use of generic lots (an approach which requires that lots of one given type are of similar value, irrespective of their specific frequency). This question depends on the nature of the interference environment both within the 2.6 GHz band itself and on the nature of the interference environment with adjacent users and with users in neighbouring countries. A number of stakeholders have, at different points in though the consultation process, expressed concerns that blocks at different frequencies might be subject to materially different levels of interference to the extent that the use of a generic lot approach could lead to an inefficient auction outcome. However, no respondent has provided any analysis of the impact of the interference environment to support this view.

5.220 The potential sources of interference which are of most relevance to this issue concern:

a) the FDD channel adjacent to the lowest frequency boundary between FDD and TDD use within the 2.6 GHz band, and the TDD channel(s) next to the FDD downlink frequencies, on account of the potential impact of base station to base station interference;

b) those TDD and FDD channels near to the boundaries between FDD and TDD use within the 2.6 GHz band which could be more susceptible than others to terminal to terminal interference;

c) the frequencies at the top end of the 2.6 GHz band that are closer to radar transmissions above 2700 MHz; and

d) the scope for coordination requirements with France and Ireland to differ by frequency.

5.221 All of these interference scenarios have been considered above in this Section.

5.222 Our analysis of base station to base station interference indicates that this should not create any difference in the ability to make use of standard blocks and that the modest cost of filtering should mean that it will not be materially more expensive to deploy base stations in blocks near frequency boundaries.

5.223 Our analysis of terminal station to terminal station interference demonstrates that the risk of terminal to terminal interference at the boundary between paired and unpaired spectrum is low given that unpaired base station transmissions in the 5 MHz restricted block between neighbouring paired and unpaired spectrum will need to conform to the 25 dBm/(5 MHz) limit.

5.224 The analysis of coexistence with uses in spectrum adjacent to the 2.6 GHz band, notably with respect to radar use, suggests that these adjacent uses should not materially impair the ability to use any of the frequency blocks in the 2.6 GHz band. Again, to the extent that additional filtering is required on base stations operating at the top end of the 2.6 GHz band in order to meet the tighter out of band mask that we have adopted in order to protect radar use above 2700 MHz, the cost of this additional filtering is likely to be very modest.

5.225 Finally, considerations relating to international use of the 2.6 GHz band do not indicate any reason why there should be material differential impact on the utility of different frequencies with the 2.6 GHz band.

5.226 The overall implication of the above analysis is that the interference environment should not create a material differential impact on the utility of any one lot over any another. Accordingly, we have concluded that there is no reason why an auction design based on the use of generic lots should be at risk of being inefficient on account of technical interference considerations.

Coexistence with uses in spectrum adjacent to the 2010 MHz band

5.227 In this part of Section 5 we set out our analysis and decisions regarding coexistence of uses in the 2010 MHz band with the following uses in neighbouring spectrum bands.

a) Adjacent uses in the UK – 2010 MHz boundary

- Mobile satellite service allocation (1980 to 2010 MHz)
- Fixed and Mobile service allocation (1980 to 2010 MHz)

b) Adjacent uses in the UK – 2025 MHz boundary

- Mobile and space operations services (2025 to 2110 MHz)
- Programme making and special events (2025 to 2110 MHz)
- Space research in the 2025 to 2110 MHz band
- Earth exploration-satellite in the 2025 to 2110 MHz band

Mobile satellite service allocation (1980 to 2010 MHz)

5.228 The band 1980 – 2010 MHz is allocated on a primary basis to the mobile satellite service and is identified in the ITU Radio Regulations for the satellite component of IMT-2000. The band is specified as a satellite uplink, i.e. earth to space. Adjacent band compatibility between UMTS and MSS was studied within CEPT and ERC Report 65 suggests that a 1 MHz guard band between TDD use above 2010 MHz and MSS use below 2010 MHz is needed. 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 (this effectively shares the guard band burden equally across the 2010 MHz boundary. In the December 2006 Consultation, Ofcom stated that it 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.

5.229 No stakeholders have commented specifically on the technical conditions relating to the 2010 MHz boundary in their responses.

5.230 However, we have reviewed our assessment of the appropriate technical conditions in light of the binding EC Decision 2007/98/EC[112], which was adopted in February 2007 and which requires Member States to designate and make available the bands 1980 – 2010 MHz and 2170 – 2200 MHz for Mobile Satellite Systems (MSS), including Complementary Ground Components (CGC). As a terrestrial use of spectrum, the use of CGC within the UK will require authorisation under the Wireless Telegraphy Act 2006 and in accordance with European law.[113]

5.231 Although the EC Decision does not include any provisions relating to technical band edge conditions, the discussions on this Decision were based on the assumption that the full 30 MHz uplink band (1980 – 2010 MHz) would be available for CGC use. Subsequent work on the Article 95 Decision and the EU selection and award process has proceeded on the basis that the full 2x30 MHz is available for award to a number of competing satellite operators.[114]

5.232 Work within CEPT on least restrictive technical conditions for WAPECS implementation has resulted in the development of CEPT Report 19. Whilst covering use of the band 2010 – 2025 MHz, Report 19 does not consider the implications of CGC use in the bands below 2010 MHz. However, the conclusions drawn from the analysis of FDD/TDD adjacencies in the 2.6 GHz band appear to us to be directly comparable since a CGC base station operating immediately below 2010 MHz would be very similar to a base station operating in the FDD uplink portion of the 2.6 GHz

[112] 2007/98/EC: Commission Decision of 14 February 2007 on the harmonised use of radio spectrum in the 2 GHz frequency bands for the implementation of systems providing mobile satellite services. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:043:0032:0034:EN:PDF

[113] A consultation on licensing arrangements for base stations associated with CGC operating as integral parts of 2 GHz mobile satellite systems closed on 25 March 2008 (http://www.ofcom.org.uk/consult/condocs/cgcs/).

[114] This Decision is expected in 2008 with the selection process likely to be concluded in 2009.

band. On the basis of this analogy, it is reasonable to deduce that there will be a need for a 5 MHz restricted block between any CGC use below 2010 MHz and base station transmissions above 2010 MHz.

5.233 It would be possible technically to accommodate the need for a 5 MHz separation between full power use of base stations in the 2010 MHz band and CGC base stations below the 2010 MHz boundary in a number of ways. The impact of the restriction could fall entirely on the 2010-2015 MHz band, entirely on the use of CGC below 2010 MHz or some combination of these. However, the EC Decision requires that all of the 1980 – 2010 MHz band must be made available for use by CGC. Accordingly, we consider that any restriction must fall on the 2010-2025 MHz band. The revised technical licence conditions set out in section 6 reflect this requirement.

5.234 We also note that, because the frequencies immediately below 2010 MHz may be used as a CGC uplink (i.e. terminal transmit), there is a potential for terminal-to-terminal interference in the 5 MHz block immediately above 2010 MHz.

5.235 Although this revision implies a reduction in the amount of spectrum that is available in the 2010-2025 MHz band for full power use, we note that it would be possible for a future licensee of the 2010 MHz band to agree a variation to these technical conditions with a future adjacent CGC licensee. Stakeholders should note that it is possible that further work will take place in Europe on the 2010 MHz band edge and the relationship between the protection of CGC base stations operating below 2010 MHz and the use of the 2010-2025 MHz band. To the extent that the outcome of this work permits us to relax the proposed 2010-2025 MHz band licence conditions in the future, we would consider doing so as appropriate. However, we can not predict with certainty the outcome of any such further work, and bidders interested in the 2010 MHz lot in the auction should take this into account

Fixed and Mobile service allocation (1980 to 2010 MHz)

5.236 The fixed and mobile allocations in the 1980 to 2010 MHz band have no assignments in the UK at present and we do not expect to authorise any further use in addition to MSS with CGC.

Mobile and space operations services (2025 to 2110 MHz)

5.237 The UKFAT indicates that assignments are made by the MoD for the mobile service in the 2025 to 2070 MHz band. The MoD has indicated to Ofcom that it currently uses this band to support mobile radio-relay links having UK-wide assignments operating with an EIRP of up to around 59 dBm (32 dBm mean power into 26.5 dBi antenna) in channels up to 8 MHz wide.

5.238 The UKFAT also indicates that assignments are made to the MoD for space operations service in 2025 to 2110 MHz. The MoD has indicated to Ofcom that it uses the band to support tele-command and control operation of satellites. It currently operates satellite earth stations at three sites within the UK (Colerne, Menwith Hill and Oakhanger) with transmissions having EIRPs of up to 76 dBW in 300 kHz.

5.239 From information received from the MoD, we have concluded that there is a particularly low risk of interference to MoD use of this band from new services in 2010 to 2025 MHz. The probability of interference from MoD use to new services in 2010 to 2025 MHz is likely to be low but cannot be entirely ruled out.

Programme making and special events (2025 to 2110 MHz)

5.240 Use of the band 2025 to 2110 MHz for PMSE is similar to their use of band 2390 to 2500 MHz, and the potential for interference at the 2025 MHz adjacency is similar to that identified for the 2500 MHz adjacency.

5.241 We have considered carefully the JFMG proposal that a 5 MHz guard band be incorporated at 2020 to 2025 MHz to help protect PMSE use but consider this as an inefficient use of spectrum resources, particularly when considering the fully usable spectrum in the 2010 MHz band will be less than 15 MHz for the reasons explained above. We also note that the existing channel arrangements for PMSE centre the first 10 MHz PMSE channel at 2035 MHz, thereby providing a 5 MHz frequency separation between PMSE use and the 2025 MHz adjacency.

5.242 However, to minimise the probability of interference into PMSE, we will require that base-stations operating within the 2010 MHz band comply with a maximum EIRP emission level of -38 dBm/MHz within the 2030 to 2055 MHz band. This requirement represents a reduction of 42dB in the maximum base station out-of-band emission level from the +4 dBm/MHz requirement proposed in the Discussion Document. We consider that this reduction is justified in order to mitigate the impact of use of the 2010 MHz band on adjacent PMSE services, while only introducing relatively modest costs in respect of filters as discussed earlier in this section. The maximum emission requirement within the 2025.7 to 2030 MHz band will be +4 dBm/MHz.

5.243 The analysis behind this revised specification of the base-station out-of-band requirement is provided in Annex 6. This analysis considers the impact of the revised specification on the scope for interference into PMSE use and shows that there is a significantly reduced probability of interference.

5.244 In summary, we consider that the technical arrangements adopted for the 2010 MHz band provide adequate measures to minimise the interference towards PMSE applications operating above 2025 MHz.

5.245 Regarding interference from PMSE use into the 2010 MHz band, we are not proposing to place any further restrictions on the use of the 2025 to 2110 MHz band by PMSE users from the time of the publication of the December 2006 Consultation. The analysis presented in that consultation on the interference potential from PMSE applications into the 2010 MHz band remains valid.

Space research in the 2025 to 2110 MHz band

5.246 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. Our decisions for this award are consistent with this Decision and we specify that the out-of-band mask at the upper edge of the 2010 MHz band must start 500 kHz inside the available spectrum. Based on the ERC report, we consider this action is sufficient to protect any UK and international use of the adjacent band for space research.

Earth exploration-satellite in the 2025 to 2110 MHz band

5.247 The band is used in the UK for telecontrol and command to EES satellites. There are currently two licensed earth stations in the UK working to two non-geostationary

satellites with a total of seven carriers at each earth station operating in the band 2048 – 2063 MHz. We consider that respecting the CEPT guard band requirement of 300 kHz from ECC Decision (06)01 is sufficient to protect the UK and international use of the adjacent band.

Conclusions

5.248 This section has addressed a wide range of factors relating to the interference environment within the 2.6 GHz band itself as well as addressing the conditions required to establish coexistence with international use and with users adjacent to the 2.6 GHz and 2010 MHz bands. On the back of this analysis we have drawn out a number of implications for the way in which spectrum can be packaged for award.

5.249 In respect of the interference environment within the 2.6 GHz band, we have concluded that:

- a 5 MHz restricted block at the boundary between FDD and TDD systems, and at the boundary between unsynchronised TDD systems, will be necessary and sufficient to manage the effects of base station to base station interference. Better transmit and receive filtering (by comparison with the minimum requirements in the existing 3GPP specifications) will be required on blocks immediately adjacent to the boundaries, but this is technically feasible and should not add materially to the cost of base station deployment.

- the impact on performance of terminal-to-terminal (mobile-to-mobile) interference will be very modest; indeed, the more detailed analysis that we have carried out indicates that this should be even less of a concern than we previously indicated in the Discussion Document, even in so-called “hot-spot” scenarios. Accordingly, there should be no material diminution of performance for users of paired (FDD) spectrum if the 2.6 GHz award leads to an outcome in which TDD terminals are used in the upper part of the 2.6 GHz band.

5.250 These conclusions have a number of implications for our approach to packaging of the 2.6 GHz spectrum for award.

- There are no technical reasons not to allow flexibility as regards the division of the band between paired and unpaired use. In particular, there is no need to constrain the award outcome to the CEPT (05)05 band-plan. Nor is there a need to place constraints on the way in which particular technologies may be deployed (such as requiring any WiMAX systems to be deployed in a half-duplex FDD mode outside of the central 50 MHz).

- The adoption to the 5 MHz block width, the 120 MHz duplex spacing for FDD systems, and the identification of FDD uplink and downlink bands, and the technical conditions that we have adopted from the CEPT (05) 05 report, are sufficient to allow operators to access the benefits of market-led harmonisation in that they will support a Europe-wide marketplace for equipment and facilitate roaming.

5.251 In reviewing the 2.6 GHz in-band interference environment we have used the technical conditions relating to block edge masks proposed in CEPT Report 19, based on the output of CEPT Working Group SE42. In doing so, we have taken full account of European regulatory work as requested by a number of stakeholders who were concerned about in-band interference issues.

5.252 Our analysis of the scope for interference with users adjacent to the 2.6 GHz and 2010 MHz bands has led us to tighten and extend the out-of-band emission limits so as to reduce the scope for interference into the following adjacent users:

a) PMSE users below 2500 MHz and above 2025 MHz;

b) radar users above 2700 MHz; and

c) prospective future operators of Complementary Ground Components below 2010 MHz (complementary to Mobile Satellite Systems operating in the 1980-2010 MHz range).

5.253 In the first two cases, the changes will provide a greater degree of protection to the adjacent users without any material adverse impact on operators in the 2.6 GHz band (either in terms of their ability to use the spectrum effectively or in terms of the costs of doing so). In the third case, the revised out-of-band emission limit below 2010 MHz may reduce the ability of an operator to use the lowest 5 MHz of the 2010-2025 MHz band. This change has been made because of our legal obligation to comply with the EC Decision on Mobile Satellite Services adopted in February 2007.

5.254 Since the Discussion Document we have also concluded Memorandum of Understanding with both Ireland and France that set out arrangements for coordination of use of the 2.6 GHz band. These are included in the Information Memorandum published alongside this Statement.

5.255 One further issue on spectrum packaging relates to the viability of using an auction design based on generic lots within the 2.6 GHz band. The technical analysis indicates that there is no reason why the in-band interference environment, or the interference environment with adjacent users, or the needs for coexistence with international uses should cause one frequency block to have a materially different utility or value to any other frequency block. Accordingly, we have concluded that there is no reason why an auction design based on the use of generic lots should be at risk of being inefficient on account of technical interference considerations.

5.256 The technical licence conditions that will apply after taking account of the changes referred to above are summarised in Section 6.

Section 6

Technical conditions

6.1 In this section we summarise the decisions we have made in respect of the technical licence conditions. These decisions reflect the analysis of the issues relating to the interference environment covered in detail in section 5, alongside the developments that have taken place in European regulatory bodies, notably the work on technical conditions for the 2.6 GHz band undertaken by CEPT project team SE42 as captured in CEPT Report 19. Table 5 provides a summary of the main elements of our decisions. The Information Memorandum and associated draft licence published alongside this Statement provide a complete description of the technical licence conditions.

Table 5: Summary of technical conditions

Area	***Decision***
Framework	The technical licence conditions will follow the block-edge-mask approach developed by the SE42 project team. This approach consists of a set of in-band radiated power limits together with a set of out-of-block radiated power limits covering the entire available spectrum bands. For the purposes of managing the risk of harmful interference to adjacent spectrum bands, the out-of-block radiated limits are extended to ±30 MHz outside the available spectrum bands.
In-band powers	**2010 – 2025 MHz and 2500 – 2690 MHz** base stations +61 dBm/5 MHz EIRP (standard) +25 dBm/5 MHz EIRP (restricted*) terminal stations +31 dBm/5 MHz TRP (mobile/nomadic terminals) +35 dBm/5 MHz EIRP (fixed/installed terminals) *The restricted power base station limit applies to a 5 MHz block between any adjacent FDD and standard TDD blocks and between any two adjacent standard TDD blocks belonging to different TDD systems.
Main characteristics of out-of-block emissions	**2500 – 2690 MHz** for base stations a composite approach is used consisting of: a baseline requirement with two limits, one (-45 dBm/MHz EIRP) designed to protect base station receivers and another (+4 dBM/MHz EIRP) designed to protect terminal station receivers; and a mask specific to individual licensed blocks (out to ±5 MHz) derived

from the current 3GPP UMTS masks

for terminal stations a single mask providing a limit of -19 dBm/MHz EIRP for frequency offsets greater than ±5 MHz from the edge of licensed blocks

2010 – 2025 MHz

for base stations the out of block mask respects the guard band requirements specified in ECC Decision (06)01 and CEPT Report 19, thus the mask starts just within the available spectrum at 2010.5 MHz for the lower portion and 2024.7 MHz for the upper portion.

for 2010.5 – 2010.0 MHz the mask is derived from the current 3GPP UMTS masks. Below 2010 MHz we are adopting a limit of -45 dBm/MHz to protect potential CGC base station receivers operating in the band 1900 – 2010 MHz.

for 2024.7 – 2030.0 MHz the mask is derived from the current 3GPP UMTS masks. Above 2030 MHz we are adopting a limit of -38 dBm/MHz to protect existing PMSE use.

For terminal stations we are adopting the same mask as for 2500 – 2690 MHz.

6.2 As set out in Section 4 above, the statutory regime under which we may award licences to use spectrum is set out in the Wireless Telegraphy Act 2006. The 2006 Act sets out our discretion to include those terms, provisions and limitations in licences as we think fit, subject to a number of limitations (see further paragraphs 4.3 to 4.5).

6.3 In light of these statutory provisions and the requirements under the RSC Decision, we have exercised our discretion in considering what technical licence conditions to include in the licences for the 2.6GHz and 2010MHz bands and have taken into account the responses to our consultations which we received from stakeholders in relation to these issues.

6.4 We consider that our decisions in this regard, which are set out in this section, are objectively justified and proportionate, and provide the most appropriate means of meeting our objectives for the award and our duties under UK and European law. They are not unduly discriminatory, either as to their object or effect and are transparent in what they seek to achieve.

The impact of European work in the SE42 project team and the RSC Decision on technical licence conditions for the 2.6GHz band

6.5 We noted in the December 2007 Auction Rules Consultation that we proposed to adopt technical conditions for the 2.6 GHz band which are consistent with the work carried out in the ECC SE42 project team under mandate from the European Commission “to develop least restrictive technical conditions for the frequency bands addressed in the context of WAPECS”.

6.6 SE42 concluded this work in November 2007 and produced a draft report (CEPT Report 19). This report was endorsed by both the RSC and ECC committees in

December 2007 and was sent by the ECC for public consultations closing on 19 February 2008.

6.7 The responses to the public consultation were considered by SE42 at its meeting in early March 2008. A number of purely editorial issues were identified. Additionally points of substance were collated into an overview of comments, together with a summary of their handling. Both the editorial issues and details of the substantive comments were forwarded to and considered by the ECC meeting in mid March 2008.

6.8 At the ECC meeting, it was agreed to forward the summary of comments directly to the European Commission and to ask the ERO to amend Report 19 to take into account the purely editorial issues. In a covering letter to the European Commission, the ECC:

- confirmed its endorsement of CEPT Report 19 as a valid basis for the development of least restrictive technical conditions for frequency bands addressed in the context of WAPECS; and

- noted that it had instructed SE42 to carry out further work on terminal-to terminal interference at 2.6 GHz as a matter of urgency. ECC commented that the deliverable from this supplementary work will be presented as advice to ETSI and can be handled in line with the normal co-operative process between CEPT and ETSI.

6.9 The implication of the latter point is that further work on terminal-to terminal interference at 2.6 GHz could, in due course, be reflected in future ETSI standards for user equipment operating in the 2.6 GHz band. Vendors would then look to ensure that user equipment complies with the relevant ETSI harmonised standard and operators would look to ensure that user equipment is used in accordance with the block-edge-masks contained in CEPT Report 19 (and reflected in the technical conditions for our award as set out above). We will continue to play an active role in SE42 and intend to submit to SE42 our recent, detailed work on terminal-to terminal interference at 2.6 GHz, the results of which are summarised in Section 5 of this Statement.

6.10 At the RSC meeting on 2 April 2008, Member States unanimously agreed a Commission decision on the 2.6 GHz band that is fully consistent with CEPT Report 19. We expect the decision to come into force in early June 2008.

6.11 There are a number of areas where CEPT Report 19 and the RSC Decision give discretion to national administrations. We list these areas below and in each case explain how we intend to proceed:

i) The split between paired and unpaired spectrum. The RSC Decision states that:

- *"Assigned blocks shall be in multiples of 5 MHz;*

- *Within the band 2550 – 2690 MHz, the duplex spacing for FDD operation shall be 120 MHz with terminal station transmission (up link) located in the lower part of the band starting at 2500 MHz (extending to a maximum limit of 2570 MHz) and base station transmission (down link) located in the upper part of the band starting at 2620 MHz;*

- *The sub-band 2570 – 2620 MHz can be used by TDD or other usage modes complying with the BEMs in this annex (i.e. the annex to the EC Decision). Outside of the sub-band 2570 – 2620 MHz such usage can be decided at a national level and shall be in equal parts in both the upper part of the band starting at 2690 MHz (extending downwards) and the lower part of the band starting at 2570 MHz (extending downwards)".*

Our decisions are fully consistent with these arrangements.

ii) The RSC Decision indicates that the maximum Base Station in-block EIRP should be +61 dBm/5 MHz and goes on to state that, *"Member States can relax this limit to 68 dBm/5 MHz for specific deployments e.g. in areas of low population density provided that this does not significantly increase the risk of terminal station receiver blocking".* We are not including such a relaxation in the technical licence conditions as part of this award. Rather we will consider any requests for such a relaxation by licensees after the award on a case by case basis, taking account of our statutory duties and, where justified, we expect to vary licences accordingly.

iii) CEPT Report 19 and the RSC Decision provide for a relaxed out-of-block mask for base stations operating at or below the restricted block maximum in-block EIRP of +25 dBm/5 MHz in cases where antennas are placed indoors or where the antenna height is below a certain height. In Section 5 (see paragraphs 5.41 to 5.49), we set out our decisions on the appropriate antenna placement restrictions. The licences will allow use of the relaxed base station mask where antennas are either placed indoors and are no higher than 10 metres above ground level or where they are placed outdoors and are no higher than 4 metres above ground level. Note that this is slightly tighter than proposed in the December 2007 Auction Rules Consultation; however we feel that this is justified on interference management grounds.

6.12 The other aspects the technical licence conditions for the 2.6 GHz band are as specified in both CEPT Report 19 and the RSC Decision. Our own technical analysis summarised in section 5 fully supports this approach.

The impact of European proposals for use of MSS (and associated CGC) use of the band 1980 to 2010 MHz band on technical licence conditions for the band 2010 – 2025 MHz

6.13 As explained in section 5, we consider that the European harmonisation requirements placed on the UK by Decision 2007/98/EC requires us to provide an adequate level of protection from harmful interference to any CGC network operating in the spectrum below 2010 MHz. We are therefore adopting a base station out-of-block limit of -45 dBm/MHz EIRP below 2010 MHz. Between 2010 and 2010.5 MHz, we are adopting the transmission limit specified in ECC Decision (06)01. The transmission limit above 2010.5 MHz will be unchanged from the level which we have previously consulted on (i.e. 61 dBm/(5 MHz) EIRP). However, it will be difficult for frequencies immediately above 2010.5 MHz to be used at full power whilst also meeting the out-of-block limit of -45 dBm/MHz EIRP immediately below 2010 MHz. In practice, the base station filter will require several MHz roll-off in order to meet the -45 dBm/MHz EIRP limit.

Stakeholder comments on Ofcom's earlier proposals for technical conditions

Spectrum usage rights (SURs)

6.14 In the August 2007 Discussion Document, we indicated that we did not intend to adopt an SUR approach to the technical licence conditions for the 2010MHz and 2.6 GHz bands. The explanation for this conclusion contained within the Discussion Document is repeated below.

6.15 "Following the publication of the December 2006 consultation, Ofcom held a series of individual meetings with interested parties where the issue of SURs was discussed. In these meetings a number of refinements to the SUR proposals were put forward to address concerns raised in responses to the December Consultation. These included moving to a modelling rather than measurement approach to enforcement and to adopt a hybrid approach that included a specific EIRP cap on individual transmitters alongside the aggregate PFD approach included in the SUR consultation. An outline of the major points raised during these discussions is as follows.

- *Some parties wanted SURs ruled out for 2.6 GHz, primarily because they were concerned that using them would unduly delay the auction.*
- *One party was very supportive and was in favour of the SUR approach including the changes.*
- *Issues raised included legal certainty, modelling accuracy, measurement areas, the level of risk in applying novel concepts to a valuable band.*
- *Most parties broadly welcomed the fact that Ofcom had revised its SUR proposals in the light of their comments but, while willing to continue to work with Ofcom on the approach, reserved judgement on whether they would change their view on the appropriateness of SURs.*

6.16 However, it was apparent that most interested parties do not believe that they need the extra protection an SUR approach might give them since, in their view, the 2.6 GHz band will likely be used for broadly similar types of services. They believe that 2.6 GHz operators should therefore be able to work together to minimise interference (similar to the way in which the current MNOs cooperate with each other to minimise interference issues between existing 2G and 3G networks). Under such a scenario they believe that the risk of interference would not be sufficiently high to merit the time and cost associated with designing and implementing SURs.

6.17 Whilst it is Ofcom's view that the SUR approach could be developed further with respect to the 2.6 GHz band, it is apparent that the vast majority of interested parties are still concerned that the SUR proposals require refinements and that any added benefit of greater certainty over interference is not perceived to be significant. There is also insufficient certainty over the time it would take to resolve the outstanding issues for Ofcom to be confident that pursuing SURs would not risk a significant delay to the award. Ofcom is therefore not proposing to pursue the SUR approach in relation to the 2.6 GHz award.

6.18 In relation to the suggestion that Ofcom should instead rely on international standards, this is clearly incompatible with the technology neutral approach proposed for this award (see the discussion in Section 8). International standards developed by bodies such as 3GPP and IEEE are specific to particular technologies and truly technology neutral standards do not exist at the present time. However, Ofcom does

acknowledge that it is very important to consider the standards that are relevant to the most likely uses of the spectrum when setting technical licence conditions and this was carefully considered when making the proposals contained in the December Consultation. For example, the transmitter spectrum masks were largely derived from existing 3GPP specifications and the proposals for specific SUR parameters were based on the relevant available standards.

6.19 Therefore, taking the above into consideration, Ofcom's current view on technical licence conditions is that it should proceed with conditions based on transmitter spectrum masks. This is consistent with the work in Europe on WAPECS being carried out by SE42 and with the interim CEPT response to the WAPECS mandate to the European Commission. Annex III of the CEPT response contains details of a block edge mask approach which, in large part, is based on our transmitter spectrum mask proposals".

6.20 Stakeholders agreed with this view and we have therefore decided that the technical licence conditions for this award will be based on the transmitter spectrum mask (or block-edge mask) approach.

6.21 Even though we will not be using them for this award, we still consider that SURs will be a valid approach in other circumstances and we have recently consulted further on this issue[115].

Exemption of handsets

6.22 In the August 2007 Discussion Document, we made the following comments in relation to responses to the December 2006 Consultation on the issue of the licence exemption of handsets.

6.23 "Some stakeholders considered that to ensure the successful development of mobile use of spectrum, it was important to ensure that the authorisation process did not prevent mobile stations (handsets) from being widely available to consumers. For that purpose, they considered that it was necessary to exempt from licensing mobile stations due to operate in the 2.6 GHz and 2010 MHz bands.

6.24 Currently, by way of background, mobile stations operating as part of 2G and 3G licensed networks are exempt from the need to operate under a licence (subject to compliance with the relevant interface requirements). Also, the main potential uses identified for the 2.6 GHz and 2010 MHz band are either identical to, or have strong similarities with, 2G and 3G use. In addition, it is likely to be in the interest of consumers, by facilitating their access to equipment for mobile use and by allowing roaming of mobile stations from other countries.

6.25 However, not all licensees in the 2.6 GHz or 2010 MHz band may wish user equipment to be exempt from licensing in the specific frequencies to which they hold rights.

6.26 *Ofcom therefore plans to amend the regulations that give effect to licence exemption after the award, at the request of interested licensees, in order to exempt mobile stations operating in connection with a licensed network that comply with its decisions in respect of technical conditions for the bands, but only in the frequencies licensed to those who request such an exemption. We therefore expect to consult on draft exemption regulations shortly after completion of the award, when licensees*

[115] http://www.ofcom.org.uk/consult/condocs/surs/

have had an opportunity to request the exemption of user terminals in their licensed frequencies".

6.27 We received only two responses to the Discussion Document in relation to the exemption of handsets. Motorola requested clarification on licence exemption of terminals and first stage backhaul. Nokia and Nokia Siemens Networks considered that terminals in the 2.6 GHz band should be exempt from licensing.

6.28 Our view on the licence exemption of handsets has not changed and we will follow the approach outlined in the Discussion Document. Our policy is to licence exempt terminals that comply with relevant technical requirements as set out in the exemption regulations (which will be the same technical requirements as those currently set out in the draft licence). As indicated previously we will consult in accordance with statutory requirements on potential amendments to the licence exemption regulations shortly after the award and following any request to that effect from interested licensees. Given our policy decision regarding exemptions for handsets, the scope of the consultation will relate to its implementation through the statutory instrument. Licensees would also be free to request us to look into the exemption of first stage backhaul at the same time and we would consider any such request on its merits at the time.

6.29 Following this initial process to exempt handsets, any later requests to exempt handsets could be considered as part of our regular annual update procedure for the licence exemption regulations.

PMSE use above 2025 MHz and below 2500 MHz

6.30 As discussed in Section 5, we have reviewed the risk of interference to operators of PMSE equipment in bands adjacent the available spectrum and have decided that additional protection for PMSE receivers is justified. As such we are imposing out-of band limits on base station emissions from the available spectrum that are based on an extension of the limits derived by SE42 for the protection of base station receivers.

- Between 2024.7 – 2030 MHz, out of band limits derived from the current 3GPP UMTS masks will apply.
- Above 2030 MHz, an out-of-band limit of -38 dBm/MHz EIRP will apply.
- Between 2495 – 2500 MHz, out of band limits derived from the current 3GPP UMTS masks will apply.
- Below 2495 MHz, an out-of-band limit of -45 dBm/MHz EIRP will apply.

Aeronautical radar use above 2700 MHz

6.31 As discussed in Section 5, Ofcom has also considered the risk of harmful interference to aeronautical radar use above 2700 MHz. We believe that it is prudent to provide these radars with sufficient protection from out-of-band emissions from base stations operating below 2690 MHz. Ofcom therefore will be imposing out-of band limits on base station emissions from the available spectrum that are based on an extension of the limits derived by SE42 for the protection of base station receivers. Above 2700 MHz an out-of-band limit of -45 dBm/MHz EIRP will apply.

Section 7

Auction design

Introduction

7.1 This section sets out our decisions on auction design for the award of the 2.6 GHz and 2010 MHz bands. These decisions have drawn on the many helpful and constructive consultation responses we have received to each of the three consultations we have held on various aspects of the auction proposals, as well as our own further work and advice from our auction design advisers. We have also tested the auction design against a diverse range of mock auction scenarios and, most recently, have reviewed the design and procedures in light of the experience of the 10-40 GHz auction.

7.2 In setting out the final auction rules and procedures for the award of the 2.6 GHz and 2010 MHz bands, it is helpful to distinguish between:

a) the key auction design choices that determine the overall auction format; and

b) the detailed auction rules and procedures for the chosen format.

7.3 This distinction is reflected in the division of this section into two main parts.

a) The first part explains the approach we have adopted to each of the key auction design choices, drawing on the proposals for auction format that we set out in both the 2006 Consultation and the Discussion Document and on the responses we received to these proposals. Within this part of Section 7, we explicitly address a number of outstanding issues that were raised on the overall auction format in responses to the Discussion Document, notably on questions relating to the use of generic lots, on the scope for external pairing and on the case for allowing contingent bidding.

b) The second part of this section covers the detailed auction rules and procedures. We have developed our proposals on auction rules and procedures, following on from the high level auction design, in each of the consultations we have held, taking account of feedback at each stage. In the second part of section 6 we discuss the responses to the most recent Auction Rules Consultation of December 2007 and present our decisions on the detailed auction rules and procedures that we are adopting.

7.4 In summary, we have decided that the award of the 2.6 GHz and 2010 MHz band will use a combinatorial clock auction format, with the following main features.

- The auction will use three categories of lot, one for the 2010 MHz band, a category of paired lot of size 2x5 MHz in the 2.6 GHz band and a category of unpaired lot of size 5 MHz in the 2.6 GHz band.

- The auction will be divided into two main stages:

  - a Principal Stage in which generic paired lots and generic unpaired lots in the 2.6 GHz band, together with the 2010 MHz band, are awarded to winning bidders; and

- an Assignment Stage in which these generic paired and unpaired lots are converted into specific frequency assignments in the 2.6 GHz band.

- The Principal Stage is further divided between:

  - the primary bid rounds where bidders indicate their preferred package of lots at a given price level for each category of lot, and the prices of each category of lot are increased until there is no excess demand (hence, the reference to this auction using a combinatorial clock format); and

  - a subsequent supplementary bids round where bidders can submit bids for other packages that differ (in terms of bid value and / or the composition of package) from those submitted during the course of the primary bid rounds.

- In both the Principal Stage and the Assignment Stage, the prices paid by the winning bidders follow the principle of a "second price rule" whereby the prices paid are set no higher than the level needed to ensure that no other coalition of bidders would have been prepared to pay more to win the spectrum[116].

7.5 Full details of the auction rules are contained in the Information Memorandum and Draft Auction Regulations which are published alongside this Statement. These details are not repeated in this Statement; however, some of the discussion in this section makes reference to concepts and terms explained in the description of the auction process in the Information Memorandum.

7.6 Interested parties should note that in this Statement, we refer to unpaired lots for lots that may be used for both base station and terminal station transmissions (for example as part of a TDD network), while in the Draft Auction Regulations, such lots are identified as individual lots.

Key auction design choices

7.7 In this first part of this Section we:

- refer back to our general objectives for the award and set out a more specific set of objectives for the auction design that flow from these;

- review the key auction design choices and final choice of auction format;

- discuss the outstanding comments raised in responses to the Discussion Document which were not considered in the Auction Rules Consultation and are relevant to these key auction design choices for the auction format; and

- discuss additional comments raised in responses to the Auction Rules Consultation that relate to these key auction design choices for the auction format.

[116] In auctions with only one lot this pricing rule gives a winning price that is equal to the amount bid by the second highest bidder. The algorithm for deriving the set of winning prices is more complicated to explain when there are more lots and package bids; but the broad principle of setting prices by reference to opportunity cost is the same.

Objectives relating to auction design

7.8 Section 3 of this Statement outlined the application of our duties to this award (see paragraph 3.21). We consider that our principal duty to further the interests of consumers, where appropriate by promoting competition, is of particular importance to this award. In fulfilling this duty, we consider that our duties to secure optimal use of spectrum, promote innovation, and secure the availability of a wide range of electronic communications services throughout the UK are also of particular significance.

7.9 We consider that an objective to promote an outcome that awards spectrum to those that can create greatest value from its use, irrespective of technology or use is consistent with the application of our duties. The design of the auction should promote this objective. An outcome which fulfils this objective is likely to generate the greatest benefits for consumers, provided that the downstream markets served by use of this spectrum are competitive. We note in this context that this award is likely to enhance competition in downstream markets.

7.10 We do not consider that it would be appropriate to modify the above objective in a way that was intended to encourage or secure any pre-defined outcome in terms of who wins the spectrum, how many bidders are successful or the amount of spectrum any successful bidder should win (subject to the discussion of conditions relating to individual bidders discussed in Section 8). We do not consider that there is an objective justification for explicit intervention designed to advantage new entrants or technologies, such as by reserving spectrum for a particular class of bidder. Any intervention of this nature would carry a high risk of regulatory failure and no respondents have suggested that we should do so.

7.11 Given the nature of prospective uses of the 2010 MHz and 2.6 GHz bands discussed in section 3, we have translated these duties and objectives for the award into a set of more specific objectives for the auction as follows.

- **To provide flexibility over size and composition of spectrum packages:** the auction needs to be flexible enough to accommodate bidders that want different amounts of spectrum in the 2.6 GHz band; we have therefore maximised flexibility in this regard by not pre-determining the size of spectrum packages that can be won in the auction.

- **To provide flexibility over the split between paired and unpaired spectrum in the 2.6 GHz band:** the economically efficient split of spectrum between paired and unpaired use is uncertain. The auction design therefore allows the bidding process to determine whether a particular spectrum block is paired or unpaired, subject to the packaging restrictions presented in section 5 (e.g. 120 MHz duplex spacing for paired lots).

- **To avoid aggregation risks for bidders:** The auction is designed in such a way as to mitigate risks that bidders acquire some spectrum but not enough to meet their needs, or that spectrum is awarded in a manner which is insufficiently contiguous resulting in the sterilisation of some lots.

- More generally **to facilitate the reduction in common value uncertainty:** bidders are likely to be serving a converging mobile broadband services market. Being able to validate 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 preferable.

- **To encourage truthful bidding:** the design aims to encourage bidders to submit bids on all packages on which they are interested and creates incentives for their bids to reflect the true valuation that the bidder places on each package.

- **To reduce the opportunities for strategic bidding behaviour:** the auction rules and procedures are designed to make it difficult for bidders to follow a strategic bidding strategy intended to exclude other bidders from winning spectrum.

- **To avoid barriers to participation:** the auction is designed not to deter participation by any type of prospective bidder, including smaller bidders as well as large, sophisticated bidders. This implies that participating in the auction should be relatively simple and low risk for bidders.

- **To design an auction that is practical to implement:** the level of complexity in the auction has been designed so as not to be so great that it becomes impractical to implement in the software required to run the auction or in the regulations required to give legal effect to the award. Equally, the design is intended to avoid being so complex for bidders to understand or participate in that they risk making material bidding mistakes.

7.12 We note that some of these objectives might be in conflict with regard to certain aspects of the auction design. For example, the objective of facilitating a reduction in common value uncertainty might conflict with the aim of reducing the opportunities for strategic bidding behaviour. Where aspects of these objectives do conflict, we have exercised our discretion as to which approach is likely best to achieve the overall objective of awarding the spectrum to those that can create greatest value from its use.

7.13 We also note that Ofcom does not have a duty to maximise revenue. For this reason, our auction design is not influenced by any objective relating to the overall amount of revenue that a particular auction design might raise.

Key auction design choices and final choice of auction format

7.14 Consistent with our objectives for the award, we have made decisions on several key auction design choices in order to aid in the specification of the most appropriate auction format. The key design choices relate to the following design characteristics:

- single or multiple lots;

- simultaneous or sequential award of lots;

- single round (sealed bid) or multiple rounds (open process with ascending bids);

- separate bids on individual lots or combinatorial (package) bidding;

- generic or specific lots;

- clock prices or bidder nominated prices; and

- first or second price rule.

7.15 We initially presented an analysis of the advantages and disadvantages of these options, along with our initial choices and the rationale behind these choices in Section 8 of the December 2006 Consultation (and in more detail in Annex 8 of that document).

7.16 Following this, and prompted by responses to the December 2006 Consultation and additional technical analysis, we presented a detailed, updated discussion of these choices in Section 5 of the Discussion Document. Having considered the further points raised in responses to the Discussion Document and also in relation to the Auction Rules Consultation, we have reached final conclusions on the key auction design characteristics listed above. These conclusions are summarised in the table below.

Table 6: Summary of decisions on key auction design issues

Design option	***Decision and brief summary of rationale***
Single or multiple lots	The auction will use multiple lots with three types of lots. The 2010 MHz band, where 15 MHz of spectrum is available, will be awarded as a single lot as the risk of an inefficient outcome is lower in this case than if the spectrum were to be awarded as several lots. The 2.6 GHz band will be awarded as multiple lots given that there is a large amount of spectrum available and that the likely spectrum needed per operator to be able to offer an effective service is smaller than the total amount of spectrum available. The amount of spectrum which different bidders need may also vary across bidders. Lots will be auctioned based on 5 MHz blocks as this is compatible with all the services and technologies that bidders are most likely to wish to provide in this band. The two types of lots in this band are paired lots of 2x5 MHz and unpaired (i.e. individual) lots of 5 MHz.
Simultaneous or sequential award of lots	The auction will use a simultaneous approach. This approach can allow bidders to manage aggregation and substitution risk across lots. In contrast, given the substitutability and complementarity of the available lots, a sequential auction would introduce significant substitution risks (as participants must bid for one lot without knowing what the price of other substitute lots will be) and aggregation risks (bidders do not know whether they will be successful in winning complementary lots).
Single round (sealed bid) or multiple rounds (ascending bids)	The first phase of the Principal Stage of the auction (the primary bid rounds) will use a multiple round, ascending bid format. There is likely to be some degree of common value uncertainty in relation to the 2.6 GHz and 2010 MHz bands, i.e. bidders will face similar uncertainties regarding the value of spectrum and could reduce that uncertainty by learning from each others' valuations through information release over multiple rounds of bidding.

	In addition, bidders may face substitution risks in this auction and a multiple round, ascending bid format which allows bidders to switch their demand to different lots in response to changes in relative prices enables them to avoid substitution risks. For example, if bidders were not able to switch demand to different lots, they could end up paying a high price for some lots when substitute lots could have been purchased at a lower price. In the case of the 2.6 GHz band, there is a particular case for using multiple rounds so that the market can be allowed to determine the amount of paired and unpaired lots in the 2.6 GHz band. This approach allows the auction dynamically to achieve an efficient outcome. The supplementary bids round in the Principal Stage of the auction will use sealed bids, as this round is designed to allow bidders to express their interest in other packages after the multiple, ascending bids rounds have been completed. The subsequent Assignment Stage will be a single round, sealed bid process. This is appropriate since the purpose of this stage is to allow bidders to express the private value that they attach to winning one set of frequencies as opposed to another. There is no need for a multiple round process to reduce common value uncertainty in this context.
Separate bids on individual lots or combinatorial (package) bidding	The auction will allow bidders to bid on packages of lots ("combinatorial" bidding). In auctions with multiple lots, bidders seeking aggregations of lots may face an aggregation risk as, when bidding for complementary lots, those bidders may have to bid separately for lots without certainty over whether, and at what price, they might win the complementary lots. The standard 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 provides some opportunity for bidders to manage their aggregation risks. However, there is always a risk that, as demand for lots diminishes towards the end of an auction, bidders may become stranded with unwanted lots. The most effective solution to this risk is to allow bidders to make "package bids" (or "combinatorial" bids), i.e. linked bids for multiple lots that are accepted or rejected in their entirety. The downside of allowing combinatorial bidding is that facilitating aggregation for larger bidders needs to be balanced against the risk that smaller bidders, who might want only individual lots or relatively few lots, may be unable to adequately coordinate their demand to displace such larger bidders. Linked to this, there is also a risk that there is often an incentive for individual small bidders in any ad hoc coalition which forms through the auction to bid untruthfully to seek to "free ride" on the other members of the coalition (that is, to bid conservatively in the hope that the other members of the ad hoc

	coalition will pick up a larger share of the cost). In the extreme, this could result in all members of the ad hoc coalition collectively bidding less aggressively than a single, large bidder and, therefore, not winning the spectrum even when it would be efficient for them to do so. This "free-rider" risk is largely addressed in this auction design by the use of generic lots during a clock phase of the auction, by the use of a second price rule which encourages bidders to bid their full value in the supplementary bid round and by our decision not to release information on individual bids (see below). On balance, we have decided that in this case the benefit of avoiding the exposure risk is significantly the more important factor.
Generic or specific lots	The auction will use generic lots. Bidders will be able to bid on three categories of generic lots (paired lots at 2.6 GHz, unpaired lots at 2.6 GHz and the 2010 MHz lot). As discussed in Section 5, the variation in the value of different lots within the same category is expected to be relatively small. The use of specific lots rather than generic lots would enable bidders to accurately express the differences in valuations between lots, but this benefit would not be large, especially when compared to the additional complexity and aggregation risks that the use of specific lots would introduce to the auction. In addition, an assignment stage (which always has to follow the auction of generic lots) can be designed so as to provide an opportunity for bidders to express preferences across specific frequencies. The use of generic lots is particularly appropriate where bidders are likely to be interested in packages of more than one lot as the auctioneer in an auction for generic lots can guarantee that most (if not all) bidders will receive contiguous frequencies. Maximising the scope for individual bidders to receive contiguous frequencies is consistent with optimal use of spectrum by reducing the number of restricted blocks that are needed between winners' assignments; it is also consistent with interested parties' preferences and requirements. The generic lot approach also makes it much easier to allow bidder demand to drive the allocation between paired and unpaired spectrum and do so in a way that is both less complex than a specific lot approach and likely to lead to a more efficient outcome.
Clock prices or bidder nominated prices	The auction will use clock prices for the primary bid rounds, and bidder nominated prices for the supplementary bids round and the assignment bids round. A clock approach is typically used when auctioning generic lots because it has a number of significant advantages when compared to allowing bidders to nominate prices for lots or packages of lots. In this case, 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. Furthermore, it reduces complexity in the auction rules and algorithms used in a standard SMRA to establish the identity of the (provisional) winning bids at the end of each round and the minimum prices for individual lots in the next round. These considerations favour all bidders but make the clock price approach particularly helpful for smaller bidders.
First or second price rule[117]	The auction will use a second price rule for both the Principal Stage and Assignment Stage. The key advantage of the second price rule, as opposed to a first price rule, is that it encourages truthful bidding and so is likely to lead to a more efficient award. In particular, under a first price rule, there is an incentive for bidders to reduce the value of their bids to less than their full valuation in order to pay as close as possible to the minimum necessary to beat others; by doing so, they take a risk of not winning at all when it would be efficient for them to do so. This is also a very significant consideration given the advantages that truthful bidding can have in helping reduce common value uncertainty in respect of the available spectrum. Its disadvantage is that bidders do not know until the end of the auction stage what they will pay and, at the end of the auction stage, it may not be immediately apparent why they pay what they do. However, a bidder can only be required to pay as much as its bid or less, never more; and in the Principal Stage, the level that the clock prices reach will give bidders some feel for the potential outcome where lots are strongly contested.

7.17 Based on the conclusions set out above, the award of the 2.6 GHz and 2010 MHz bands will use the following.

- A combinatorial clock auction format using generic lots during the primary bid rounds - this open phase of the auction will facilitate the reduction in common value uncertainty and reduce the number of packages for which bidders need to submit supplementary bids (where different packages comprise different numbers of lots of one or more type).

- A sealed bids format with bidder nominated prices for packages containing generic lots (subject to constraints) for the supplementary bids round - this round allows bidders to express interest in packages other than those in which they bid in the primary bids round and to express their full value for these packages (to the extent that they were not able to do so in the primary bid rounds).

- A second price rule to select the highest value combination from all bids submitted in both the primary bid rounds and supplementary bids round, subject to a set of rules that are designed to meet the objectives set out earlier in this

[117] Under a first price rule a winning bidder pays what it bid. The principle of a second price rule is that a winning bidder pays a price equal to the value bid by the second highest bidder. Where there is more than one lot under auction the application of this rule becomes more complex but the principle remains the same.

section relating to the efficient organisation of users of the band with the assignment of contiguous frequencies.

- A sealed bids format with bidder nominated prices for packages containing specific lots in the Assignment Stage - this stage is required to convert generic lots into specific frequencies and it will allow bidders winning generic lots in the Principal Stage to express the value that they place on being awarded one set of frequencies as opposed to another. It will use a second price rule to establish prices that bidders will pay when being awarded specific frequencies.

7.18 Full details of the auction process and rules are contained in the Information Memorandum and Draft Auction Regulations which are published alongside this Statement.

Outstanding comments raised in responses to the Discussion Document which are relevant to the key auction design choices and auction format

7.19 In this sub-section, we review a small number of outstanding comments raised by stakeholders in response to the Discussion Document which were not covered in detail in the Auction Rules Consultation and are relevant to the overall auction format.

7.20 The majority of comments raised in responses to the Discussion Document which relate to the auction format, rules and procedures were discussed in detail in the Auction Rules Consultation. However, there were a small number of issues raised by stakeholders which related to key choices for the auction format which we did not address in the Auction Rules Consultation. These related to suggestions that the auction should:

i) use specific lots rather than generic lots;

ii) include a facility to enable the external pairing of spectrum in 2570-2620 MHz with other spectrum bands (such as the existing TDD holdings of the 3G operators);

iii) introduce contingent bidding dependent on whether or not unpaired spectrum is present at the top of the 2.6 GHz band (with this suggestion being linked to a proposal that WiMAX use outside of the central portion of the CEPT band plan could deploy a half-duplex FDD profile); and

iv) adopt a staggered approach to the award for the 2.6 GHz band with only the central 50 MHz being awarded in the first instance.

7.21 At the time of the Auction Rules Consultation we were still considering aspects of these comments and suggestions. The first three issues are considered in the following paragraphs. The proposal to hold an initial award of the central 50 MHz of the 2.6 GHz band is discussed in section 3 where we conclude that we should proceed with the full award.

Generic lots

7.22 In both the December 2006 Consultation and the Discussion Document we set out a number of reasons in favour of using generic lots in the Principal Stage of the auction, rather than adopting an auction design using specific lots (i.e. lots defined in terms of specific frequencies). The generic lot approach should be efficient so long

as differences in value between lots at different frequencies in a given category of lots are relatively small. If this is so, then the differences in value between lots at different frequencies can be reflected in the Assignment Stage of the auction. If, on the other hand, there are large differences in value between lots at different frequencies, then a generic lot approach could give an inefficient outcome (to the extent that different bidders discount their Principal Stage bids in different ways in order to reflect the risk of ending up with frequencies that they value less in the Assignment Stage). The judgement of whether to adopt a generic lot or specific lot approach therefore depends on:

- the degree of variation in value between lots (of a given type) at different frequencies; and

- the ability of a specific lot approach to meet the auction objectives more effectively.

7.23 Those respondents who expressed concern with the use of generic lots focused almost entirely on the first of these considerations, identifying a number of reasons why the valuation of lots within the paired and unpaired categories may vary, including in-band adjacencies and the impact of radar use above 2700 MHz. Some were also concerned that the generic lot approach would make it difficult to pair specific lots in the centre band (2570-2620 MHz) with spectrum in other bands, such as the existing 3G TDD spectrum. (We discuss the issue of external pairing separately below.)

7.24 In response to the concerns on potential for the valuation of lots to vary within the band, we reviewed the scope for in-band adjacencies and external interference effects to affect the value of lots and presented our findings in Section 3 of the Discussion Document. Our conclusion at that time was that these effects were sufficiently small and that there was not likely to be any significant efficiency loss from using generic lots in the Principal Stage of the auction.

7.25 A number of respondents to the Discussion Document were satisfied by the further evidence presented in the document and agreed with the proposal to use generic lots in preference to specific lots. However, some respondents, while welcoming the further information provided, continued to have concerns about the potential for interference and questioned some of the technical conclusions that underpinned the assessment that there would not be significant differences in value between lots at different frequencies.

7.26 We set out our final assessment of these issues in Section 5 of this Statement, at paragraphs 5.219 to 5.256 where we conclude that there are no grounds to believe that the value of paired or unpaired assignments in the 2.6 GHz band would be particularly sensitive to frequency.

7.27 We also note that no stakeholder has put forward evidence to support the view that there could be large differences between frequencies or proposals for an alternative auction based on the use of specific lots that we can evaluate. Moreover, we consider that the generic lot approach has a number of highly attractive properties in terms of its ability to meet the objectives for auction design. In particular, it will make it easier to allow flexibility between the amount of paired and unpaired spectrum.

7.28 In summary, we are confident that an approach based on the use of generic lots for each category in the 2.6 GHz band is likely to deliver an outcome which is consistent

with the objectives that we set out above. It is also likely to be less complex for bidders.

External pairing

7.29 We have set out our analysis of the effects of modifying the auction design to accommodate external pairing bidding options in paragraphs 5.33–5.53 of the Discussion Document. We consider how accommodating such options would impact on likely auction outcomes as well as the extent of benefits likely to be generated by such a change. Our conclusion is that facilitating such a change in the auction design would introduce a disproportionate amount of complexity compared to any potential benefit.

7.30 Most of the respondents who had raised the question of external pairing in response to the original Consultation Document did not raise the issue again in their response to the Discussion Document. However, two stakeholders reiterated their view that we should include a facility to enable external pairing, with one of these repeating this in its response to the Auction Rules Consultation. The respondent who favoured external pairing in their reply to the Auction Rules Consultation commented that Ofcom had not conducted a proper analysis of the potential for external pairing. In contrast another response to the Auction Rules Consultation urged us to not include a facility to enable external pairing.

7.31 As noted above, we set out an analysis of this issue in the Discussion Document. Neither of the two respondents who continued to express a view that the auction design should directly facilitate external pairing provided any evidence that contradicted the analysis in the Discussion Document. While we received credible and multiple expressions of market interest in use of the unpaired spectrum for use by unpaired technologies, we did not receive similar clear expressions of interest in using the spectrum for externally paired use. Neither of the respondents who continued to favour the facilitation of external pairing explicitly stated that they would be interested in bidding for unpaired spectrum as part of an externally paired bid option. We also note that Orange and T-Mobile have indicated an intention to use their currently unused unpaired 3G spectrum (that was mooted for pairing with the 2.6 GHz band) to provide a mobile TV service.[118]

7.32 In making decisions on auction design, we are required to make trade-offs between enabling the maximum number of potential outcomes and limiting the complexity of the auction process. In this particular case, it does not seem clear that the benefits resulting from specifically enabling external pairing by making changes to the auction design would outweigh the considerable extra complexity and risks that this would introduce. As such, we have not modified the auction format to include a facility to specifically favour the external pairing of spectrum in the 2.6 GHz band with other spectrum bands.

Contingent bidding

7.33 A number of stakeholders with an interest in the 2.6 GHz band being used for FDD applications have expressed strong concerns about the auction allowing an outcome in which TDD mobiles are allowed to transmit in the top part of the 2.6 GHz band (2620-2690 MHz). This relates to flexibility in the award and whether we limit the amount of unpaired spectrum (to 50 MHz out of 190 MHz) or whether we allow the auction to determine how the band is used. They have argued that this outcome

[118] http://www.vnunet.com/vnunet/news/2209800/mobile-orange-team-mobile-tv

would result in an increased level of interference into FDD mobiles and that this would reduce the value of the 2.6 GHz band for paired / FDD use (by comparison with a situation in which there were no TDD mobile transmissions in the top half of the 2.6 GHz band).These respondents argued that the auction should not allow TDD mobile transmissions in the top half of the band at all (e.g. suggesting that no flexibility should be allowed in the 2.6 GHz band plan and that WiMAX use should be restricted to a H-FDD standard). One respondent also argued, without prejudice to their view that TDD transmissions should not be allowed in the top half of the band, that if such transmissions were nevertheless to be allowed, then the auction design should allow bidders to make contingent bids for paired spectrum.

7.34 We introduced the concept of contingent bidding in the Discussion Document (paragraphs 5.23 to 5.32) where we set out the pros and cons of such an approach. The judgement on whether to include the contingent bidding option depends on:

- the risk that the absence of a contingent bidding option could lead to an inefficient outcome (e.g. by bidders interested in paired spectrum submitting lower value bids which results in less spectrum being allocated to paired applications than would have otherwise been the case); and

- the costs and risks that the introduction of contingent bidding could, unavoidably, give rise to issues relating to auction complexity and to scope for strategic bidding behaviour by bidders interested in paired spectrum.

7.35 Section 5 discusses the further evaluation that we have undertaken on the effects of mobile-to-mobile interference, and the risk of blocking in particular. We conclude (see paragraphs 5.219 to 5.226) that there should be very limited additional interference to FDD mobiles caused by TDD transmissions in the top part of the band, should the auction result in a departure from the fixed CEPT band plan in ECC Decision (05)05. Accordingly, we consider there is a low risk that the auction outcome will be less efficient as a consequence of not including a contingent bidding option. Conversely, we consider that costs and risks of including the contingent bidding option are significant for the reasons set out in paragraphs 5.23 to 5.32 of the Discussion Document. In particular, the inclusion of a contingent bidding option could create the opportunity for undesirable strategic bidding behaviour by those interested in acquiring paired spectrum[119]. We have therefore decided not to include contingent bidding in the auction design.

Comments raised in responses to the Auction Rules Consultation which are relevant to key auction design choices and the auction format

7.36 While some respondents to our consultations have been very supportive of the auction format discussed earlier in this section, a small number have continued to express concerns about this choice of auction format in responses to the December 2006 Consultation, the Discussion Document and the Auction Rules Consultation. In addition to the issues already considered above, the following points were made by one or more MNO in their responses to the Auction Rules Consultation:

[119] Bidders interested in acquiring paired (FDD) spectrum have a common interest in it being more difficult for other bidders to win unpaired (TDD) spectrum. If there were relatively few FDD bidders and they decided to submit only low-value bids (or, indeed, no bids at all) in the first sub-auction (where unpaired lots are allowed to be assigned in the upper part of the band from 2620-2690 MHz range), but to bid full value in the second sub-auction (where no downlink TDD is permitted in the upper part of the band), then this would bias the outcome towards the second sub-auction and make it much more likely that TDD would be restricted to the central 50 MHz (including guard blocks).

i) the chosen auction format is novel and complex and has not been subject to sufficiently rigorous testing. Ofcom should have tested the preferred design against other candidate designs, and shared such results with potential bidders prior to this stage in the process. Ofcom should also have provided more analysis on their comparison of candidate auction formats;

ii) an apparently successful "technology neutral" auction of 2.6 GHz spectrum licences has been run in Norway using a standard simultaneous multiple round ascending (SMRA) design;

iii) one respondent provided specific examples which, they argued, demonstrated the inefficiency of the auction design;

iv) allowing the market to determine the split between paired and unpaired spectrum in the 2.6 GHz band is inherently discriminatory against bidders interested in paired spectrum and that we had not demonstrated the qualitative and quantitative benefits of such an approach;[120]

v) Ofcom should wait until it has had a chance to evaluate the results of the 10-40 GHz auction which uses a similar auction format before making conclusions on the auction format for this award; and

vi) potential bidders should have the opportunity to understand the proposed auction design through a mock auction before Ofcom undertakes the statutory consultation on the regulations containing the auction rules.

7.37 We discuss each of these issues in turn in the remainder of this sub-section.

7.38 In summary, we note the concerns raised by some respondents with regard to the chosen auction format. All auction formats are subject to some measure of risk and uncertainty and no single format will ever guarantee an optimal outcome. However, based on all the evidence available to date, both from running other spectrum auctions and in the extensive analysis carried out in relation to this auction, we remain of the strong opinion that the proposed auction format is the most appropriate to adopt in order to meet the particular objectives for the auction of spectrum in the 2.6 GHz and 2010 MHz bands.

Novelty and complexity of the auction format

7.39 We agree that the proposed auction format is novel and that a two-stage combinatorial clock auction of this type (with a subsequent Assignment Stage) had not been used previous to the recent Ofcom award of spectrum at 10-40 GHz[121]. However, we do not agree that the format is overly complex. In fact, one of the key reasons for choosing this auction format over one of the alternative formats (specifically, a combinatorial SMRA) is the reduced complexity provided by the new format. Moreover, the fact that this general auction format has now been tested in practice in the 10-40 GHz auction completed in February 2008 means that it is no longer true to say that this auction format is untried. As discussed further below, the auction design generally performed well in the 10-40 GHz award.

[120] This was linked by the respondent to the question of whether external pairing would be feasible under the proposals laid out in the Discussion Document and the Auction Rules Consultation.
[121] http://www.ofcom.org.uk/radiocomms/spectrumawards/completedawards/1040award/

7.40 As set out in previous consultations, the new format is based on the combinatorial SMRA format but avoids the complications that make such auctions tricky to implement. For example, in each and every round of a combinatorial SMRA bidders may be required to submit extensive information about their bids across many different packages of lots, and, furthermore, it is not clear on what basis bids for packages of lots in one round should be translated into minimum prices for individual lots to apply in the following round.

7.41 The combinatorial clock auction proposed for the 2010 MHz and 2.6 GHz award 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.

7.42 In previous consultations, we have provided some specific analysis comparing the proposed auction formats with alternative auction formats. For example, in the December 2006 Consultation, Paragraphs A8.31–A8.37 of Annex 8 compares a combinatorial clock auction to a simple clock auction and a combinatorial SMRA auction. In the Discussion Document, paragraphs 5.54–5.57 present our reasons for using a combinatorial clock approach rather than the traditional SMRA approach used in previous auctions. We have provided clear analysis in each of the three published consultation documents of our rationale for the decisions that have led to this choice of auction format. We consider that this analysis is conclusive and it is supported by independent auction advice. We also note that throughout three separate consultations on this award no respondent has put forward any detailed proposal for an alternate auction design nor, as a result, attempted to consider how an alternate auction design would address the specific challenges associated with the award of these bands.

7.43 The key decisions on technology neutrality, spectrum packaging and key auction design choices have effectively narrowed down the choice of auction formats available to us to two – combinatorial clock and combinatorial SMRA. As noted earlier, our view is that there are compelling reasons for choosing combinatorial clock over combinatorial SMRA.

7.44 It is also worthwhile to consider the chosen auction format with particular reference to one of our key objectives for the award: enabling all bidders, regardless of the technology they wish to use in the bands, to compete fairly and effectively in the auction. Section 4 sets out how this objective is translated into the application of technology and service neutrality to the licences for the 2.6 GHz and 2010 MHz bands. This objective, in conjunction with the potential use of the bands by both paired and unpaired technologies, has direct implications for the final auction format and, specifically, for the decision to use a combinatorial clock auction in preference to a more traditional SMRA.

7.45 The application of our objectives leads us to the view set out in Section 4 that it is not appropriate for the regulator to decide on the exact split between paired and unpaired technologies; instead, the market will be allowed to decide this split. In order to promote the efficient use of spectrum and ease uncertainty for bidders over their prospective interference environment, however, it is appropriate to group paired and unpaired spectrum in separate contiguous blocks which would minimise the number of boundaries between paired and unpaired lots. A standard SMRA auction format could not be relied upon to produce such a grouping of paired and unpaired spectrum, as bidders must bid for individual lots without certainty as to the type of

use that a winner of adjacent spectrum may deploy. By contrast, a combinatorial clock auction format should ensure an efficient separation of paired and unpaired spectrum, as paired and unpaired users will be packed in separate parts of the band and will receive contiguous frequency ranges.

Testing of the auction design

7.46 We have conducted a programme of testing and evaluation of the auction design in order to validate the theoretical benefits using our external auction advisers. Results of the tests have confirmed our understanding that the combinatorial clock auction format is a suitable format for this award. In particular, our advisor's report on the testing commented as follows on the performance of the auction with respect to six measures.

- *Efficiency*. The outcomes were highly efficient in full-scale mock auctions with realistic preferences and well-motivated subjects.
- *Robustness*. The desirable properties of the combinatorial clock auction were robust to different levels of competition and different demand structures.
- *Risk*. Variation in outcomes was the result of different valuation models. High efficiency and other desirable properties were observed in all mock auctions.
- *Simplicity for bidders*. Subjects were able to understand the auction format and participate in the full-scale mock auction after only a few hours of training. Strategic considerations were easy to manage.
- *Revenues*. The mock auctions achieved competitive revenues. There was little tendency to overbid or underbid.
- *Simplicity for the auctioneer*. The full-scale mock auctions were readily conducted. The mock auctions demonstrated the feasibility of implementation.

7.47 We plan to use some of the results from these tests at a forthcoming seminar. The information provided in this Statement, in the Information Memorandum and in the draft Regulations will also allow interested parties to carry out their own testing if they wish to do so.

2.6 GHz award in Norway using a SMRA design

7.48 One respondent pointed out that Norway had successfully held an auction of the 2.6 GHz band in November 2007 using an SMRA design[122]. They made this point in the context of their comments that Ofcom had not given enough consideration to alternative auction formats.

7.49 Publicly available information on this auction is limited; in particular, there is no detailed analysis of the Norwegian auction which we can use to inform the approach that we take in the UK. It is difficult to determine the extent to which the auction outcome was efficient as measured against the objectives set. What may be an appropriate choice for Norway is not necessarily appropriate for the UK.

7.50 There are (at least) two important respects in which the Norwegian auction design reflects different objectives to ours.

[122] Specifically, the Norwegian auction used a format known as an 'SMRA with augmented switching'.

- The Norwegian auction placed constraints on the way that the 2.6 GHz spectrum could be allocated between bidders (both in terms of the sizes of individual packages that could be won and in terms of the split between paired and unpaired lots, with a constraint on the maximum amount that could be used as unpaired spectrum). Our objectives place more emphasis on the value of greater flexibility, both in terms of the split between paired and unpaired use, and in terms of the amount of spectrum that individual bidders can win; both aspects of added flexibility could facilitate substantial efficiency gains in UK conditions.

- The spectrum packages in Norway were split into six regional lots; this added a significant layer of complexity which had to be taken into account in the auction design to limit aggregation risks for bidders wishing to aggregate the regional lots to achieve national coverage. We are auctioning national lots and this materially changes the factors that need to be accommodated within the auction design.

7.51 The SMRA with augmented switching was one of the auction formats that we considered as an option for this award. One of our auction consultants for this award had experience of implementing an SMRA with augmented switching in a previous auction in Norway, and so was well positioned to advise on the strengths and weaknesses of this format for our circumstances. Two key reasons why Ofcom decided to reject this format for this award were that: (a) it provides only limited scope to allow the market to determine boundary between paired (FDD) and unpaired (TDD), so cannot guarantee an efficient split; and (b) this format cannot guarantee that bidders will receive contiguous spectrum.

Arguments regarding inefficiency of the auction design

7.52 The same respondent provided an example of a potential demand scenario which, it claimed, demonstrated that Ofcom's preferred auction format (and, in particular, the separation of the auction into a stage based on generic lots, followed by an Assignment Stage) would result in an inefficient outcome.

7.53 However the example assumed that bidders had radically different valuations for particular lots within the same category of "generic" lot (in this case, a non-zero valuation for one lot and a zero valuation for another lot in the same category). We agree that the generic lot approach will not be efficient if different lots in the same category are of substantially different values; and this example takes difference in values to its logical extreme. However, as discussed above, we do not consider that the value of lots in the 2.6 GHz band should differ materially according to frequency in general.

7.54 The one special case that could lead to a materially different valuation of a specific frequency would be if a bidder was interested in a particular unpaired lot in order to create an external pairing with another spectrum holding. However, no stakeholder has come forward with a clear requirement to use the spectrum in that way and, as discussed earlier, we consider this to be a very unlikely scenario and one which would certainly not justify a major overhaul of the auction design, creating a new and far more material set of risks and complexities in the process.

Arguments that allowing the market to decide the split between paired and unpaired is inherently discriminatory

7.55 The same respondent argued that Ofcom's preferred approach is inherently discriminatory against those potential bidders more interested in paired use of the spectrum because:

- users of unpaired spectrum can bid for both paired and unpaired parts of the band, while bidders interested in paired spectrum cannot effectively use unpaired spectrum under the current proposals;

- as such, if there is excess demand for paired spectrum this will have to be addressed by an increase in the price, while any excess demand for unpaired spectrum can, in the first instance, lead to a decrease in the supply of paired spectrum.

7.56 These arguments were linked by the respondent to Ofcom's proposal not to make changes to the auction design to facilitate external pairing. As explained in paragraph 7.32, we do not think there is a strong case to make these changes as doing so would introduce a disproportionate amount of complexity compared to any potential benefit.

7.57 It is important to note that the limit on the amount of paired spectrum available in the award is a direct function of the design of paired technologies (and the associated duplex split[123]). This pairing has been agreed across Europe and, as a result of extensive technical work in a number of European fora resulting in CEPT Report 19, is set out in the RSC Decision relating to the 2.6 GHz band. In contrast, the design of unpaired technologies allows inherently more flexible use of spectrum and the potential to use all of the available spectrum rather than just a part of it. Moreover, excess demand for unpaired spectrum does not automatically lead to a decrease in the supply of paired spectrum as paired users can still win the maximum available paired spectrum depending on their bids.

7.58 The RSC Decision supports a flexible approach to allow the market to decide the split between paired and unpaired spectrum in the 2.6 GHz band, and for the reasons set out above, we do not therefore agree that this approach is inherently discriminatory against bidders interested in gaining access to paired spectrum.

Evaluation of the results of the 10-40 GHz auction

7.59 We note that the 10-40 GHz auction was completed successfully in February 2008. This has given us the opportunity to undertake an initial evaluation of the performance of this particular auction format, drawing on a review of the auction results by our external auction advisers as well as our own internal assessment. Separately, we have received feedback from participants in the auction via an external research organisation that we commissioned to carry out an interview programme for this purpose (alongside feedback received directly from some participants).

7.60 The assessment of our external auction advisors is that the 10-40 GHz auction, and its combinatorial clock format, facilitated a highly efficient outcome with many winners. The use of generic lots greatly simplified the bidding and bidders had strong incentives to submit truthful bids in the supplementary bids round, particularly as a result of the second price rule.

7.61 The feedback from participants was generally very positive, on both the process and results of the auction, which they felt was easy for them to participate in. We did

[123] Given the need for a duplex spacing of 120 MHz between FDD uplink and FDD downlink, as mandated in the RSC Decision agreed on 2 April 2008, it is not possible for frequencies in the range 2570 to 2620 MHz to be paired with frequencies in the 2500-2570 MHz range or with frequencies in the 2620-2690 MHz range.

receive some feedback suggesting that Ofcom should in future adapt some details of the process for auctions where bid values would likely be significantly higher (such as the 2.6 GHz auction). These very helpful suggestions included points relating to the scheduling of rounds, to the setting of deadlines for deposit payments, and to some practical aspects of managing the auction process. We will consider these points further and may, as a result, change certain details of the auction process for the 2.6 GHz award. We will reflect any such changes to the auction process in the information guide for bidders which we will issue nearer the time of the auction.

7.62 Feedback indicated that the participants were happy with the outcome of the award and felt that the auction had worked well. There were only two areas where the participants indicated that they had experienced some difficulty. Some participants with more complicated bidding strategies expressed a desire for more guidance on making supplementary bids. More generally, most participants indicated that they had found it hard to understand why the prices they paid in the end were as they were – i.e. very much lower than their highest bid prices in this auction – although they were satisfied with the result. They also commented that they found it hard to explain the prices paid to their Boards and to other internal stakeholders. Since these interviews were conducted we have published an explanatory note on the method of calculating the prices paid in the 10-40 GHz auction. The feedback none the less suggests that we should do more to help bidders understand and explain to their internal stakeholders the principles and practice behind the derivation of base prices. We intend to work with potential bidders to do this during the period between the publication of this Statement and the start of the auction. We envisage that we will do this largely through further seminars, mock auctions and stakeholder meetings.

Mock auctions

7.63 We intend to hold mock auctions for interested parties before the main auction. We also intend to publish a copy of the software that will be used to calculate the winning allocation and prices as we have done for other auctions before the auction takes place so that interested parties can familiarise themselves with this.. Interested parties also had the opportunity to participate in two mock auctions for the 10-40 GHz and L-Band awards, both of which adopted the combinatorial clock auction format. Although there are obvious differences between these awards and the 2.6 GHz award, these mock auctions still provided an opportunity for interested parties to obtain valuable first hand experience in understanding the process and dynamics associated with the combinatorial clock format.

Detailed auction rules and procedures

7.64 The second half of this section considers detailed auction rules and procedures within the context of the overall auction format discussed above.

7.65 We first set out our proposals on auction rules and procedures in Annex 8 of the December 2006 Consultation. A more complete set of rules and procedures was set out in Annex 11 of the Discussion Document. In response to detailed responses to the Discussion Document, we made some changes to our proposals and consulted further on these in the Auction Rules Consultation of December 2007. The final set of auction rules and procedures is described in the Information Memorandum and contained in the Draft Auction Regulations which are published alongside this Statement.

7.66 The sub-sections below provide further details on the reasoning behind our final choices of detailed auction rules and procedures. To do this, we:

- provide a short description of the final auction process;
- review the changes to detailed rules and procedures as proposed in our Auction Rules Consultation and discuss comments received from stakeholders on the proposals contained in the Auction Rules Consultation; and
- summarise the changes we have made to the auction rules and procedures from those contained in the Auction Rules Consultation.

Short description of the final auction process

7.67 The award process proceeds in five stages, as described below.

Application Stage

7.68 Prospective bidders submit their applications to participate in the award process, including initial deposit.

Qualification Stage

7.69 We determine which applicants are qualified to bid. The determination is based on a check of the applications and initial deposits, and assessment of bidder groups. We announce the number and identity of the qualified applicants. Those qualified applicants then have an opportunity to withdraw from the process by a date that we will specify. The remaining participants after the last day for withdrawal are bidders and are committed to accepting a licence at the reserve price, subject to the outcome of the auction. We announce the number and identity of the bidders. If there is only one bidder, the bidder will be entitled to select the frequency lots it wishes to purchase (subject to such restrictions as the spectrum cap) and the award will then progress directly to the Grant Stage. If there is more than one bidder, then a bidding process is required.

Principal Stage

7.70 The Principal Stage of the auction determines the identity of the winning bidders, the number of lots of each type that they will receive, the allocation of spectrum between paired and unpaired lots within the 2.6 GHz band and whether or not there are any split awards of unpaired spectrum.

7.71 The available lots are described in the table below.

Table 7: Categories and lots available in the auction

Band and category	*Number of lots available*	*Spectrum endowment*	*Eligibility points associated with lots*	*Reserve price per lot*	*Minimum bid size (in lots)*
2010-2025 MHz lot	1	1 x 15 MHz	2 points for the lot	£100,000	1
2.6 GHz – Paired lot	Between 0 & 14	2 x 5 MHz	2 points per lot	£100,000	1
2.6 GHz – Unpaired lot (referred to as individual lot in the Draft Auction Regulations)	Between 9 & 38	1 x 5 MHz	for n contiguous lots, eligibility is *n – 1 points* for n lots split across 2 contiguous assignments, eligibility is *n – 2 points*	£50,000	2
2.6 GHz – Guard block†	0 or 1	1 x 5 MHz	N/A	N/A	N/A

† Bidders do not bid for guard block in the Principal Stage of the auction; rather whether there will be a guard block is determined by the outcome of bidding for the three categories of lots. The guard block, if part of the Principal Stage outcome, is made available to bidders in the Assignment Stage. There is another case where a block that is not awarded in the Principal Stage becomes available to bidders in the Assignment Stage (block 38) when blocks 13 and 37 are awarded as a paired lot but block 14 is awarded as an unpaired lot.

7.72 The Principal Stage is divided into two phases. The first phase covers the **primary bid rounds** which follow a clock auction format. Bidders make a single bid each round for a package of lots across the three categories in response to a set of prices notified to them by us (one price per lot for each category of spectrum). Note that there may be a guard block at the boundary between paired and unpaired spectrum at block 24 (2615-2620 MHz) but that primary bids are for lots and do not include this potential guard block.

7.73 In the primary bid rounds, any bid for packages containing unpaired lots within the 2.6 GHz band is contingent on all unpaired lots in that bid being contiguous. This has the implication that if such a bid was successful, any unpaired lots awarded to a particular bidder must be located either in the lower unpaired area (i.e. below block 24) or the upper unpaired area (i.e. from block 38 downwards), and not split across the two areas.

7.74 For unpaired 2.6 GHz lots, prices are increased in the next primary bid round if there is excess demand for the 2.6 GHz band as a whole and demand for unpaired 2.6 GHz lots exceeds nine. For paired 2.6 GHz lots, prices increase whenever there is excess demand for the 2.6 GHz band as a whole or demand for paired 2.6 GHz lots exceeds 14. For the unpaired 2010-2025 MHz lot, the price increases whenever there is excess demand for this lot. The primary bid rounds continue until (a) there is no excess demand in any category and (b) it would be possible to accommodate all demand for unpaired lots in accordance with the bids (i.e. without a split award). During the primary bid rounds, bidders may be required to top up their deposits in order to continue bidding in subsequent primary bid rounds.

7.75 The second phase is the **supplementary bids round**, which always follows the primary bid rounds. This is a single round sealed bid process, in which bidders have the opportunity to make multiple, mutually exclusive bids for packages of lots across categories, subject to constraints created by their primary round bids. In the case that

bidders have submitted a primary bid that included unpaired lots or include a supplementary bid that contains unpaired lots, they will also be allowed to submit further bids for the packages with the same eligibility (i.e. same number of blocks with standard base station powers) contingent on unpaired spectrum being split into two parts of defined size (which can be assigned to either the upper or lower areas of the band). At the same time, bidders must top up their deposits, such that they have on deposit a specified proportion (not required to be greater than 50%) of their highest bid made across both the primary bid rounds and the supplementary bids round.

7.76 We then identify the highest value combination of bids that can be accommodated, drawing on all valid bids from the primary and supplementary bids rounds and taking at most one bid from each bidder. This determines the number of lots in each category that each bidder will win. A 'base price' for each winning bid is also calculated according to a second price rule. The outcome determines the allocation of lots between paired and unpaired in the 2.6 GHz band, whether there are split awards for unpaired lots and whether there is a guard block at block 24.

7.77 Winning bidders need to top-up their deposit to match the base price of their winning bid.

Assignment Stage

7.78 The Assignment Stage determines how the available frequencies within the 2.6 GHz band that are assigned to paired, unpaired and guard blocks are distributed amongst the winning bidders from the Principal Stage. Bidders participate in two parallel, sealed bid auctions, one for the paired lots and the other for the unpaired lots, and can make 'assignment round bids' for particular ranges of frequencies compatible with the number of lots that they won in the Principal Stage. The guard block, if there is one, will be automatically assigned to the winner of the unpaired assignment that is adjacent to it (i.e. the assignment that includes block 23). There is another case where a block that is not awarded in the Principal Stage becomes available to bidders in the Assignment Stage (block 38) when blocks 13 and 37 are awarded as a paired lot but block 14 is awarded as an unpaired lot; in that case block 38 is automatically awarded to the winner of block 37.

7.79 We then identify the highest value combination of bids that can be accommodated, subject to all paired lots and all unpaired lots (or two blocks of contiguous unpaired lots in the case of a split award) being awarded in contiguous ranges. A final price for each bidder is also calculated, which combines the base price and any additional prices arising from the Assignment Stage.

Grant Stage

7.80 After the conclusion of the Assignment Stage, the award progresses to the Grant Stage, in which payments are finalised, licences are granted and the auction results are published.

Consultation on auction rules and procedures

7.81 In December 2007 we published the Auction Rules Consultation which invited stakeholders to respond on a number of specific questions relating to auction rules and procedures as well inviting comments on draft auction regulations. This followed our first consultation on auction rules which we presented in Annex 8 of the

December 2006 Consultation, and a second consultation on a more complete set of rules and procedures that was set out in Annex 11 of the Discussion Document.

7.82 The specific issues which we raised in the Auction Rules Consultation are summarised in the table below.

Table 8: Proposals on auction rules and procedures in Auction Rules Consultation

Subject area	***Proposals put forward in Auction Rules Consultation.***
Auction information policy	In addition to the information release proposed in the Discussion Document (aggregate demand by category of lot at the end of each primary round): • release to bidders at the end of each primary round information on bids made on an anonymised basis; • announce publicly the base prices to be paid by each winner at the end of the Principal Stage. Provide bidders with information on all possible permutations of how the winning bids at the end of the Principal Stage can be accommodated in the 2.6 GHz band. Publish summary auction information e.g. at the end of each bidding day.
Bid options	No changes (to Discussion Document proposals) that: • in the supplementary bids round, bidders for a split unpaired assignment can not specify where each part of the split bid is located (i.e. in the central or upper part of the band); • in the Assignment Stage, a bidder does not have the opportunity to make bids contingent on who actually occupies spectrum neighbouring its own.
Eligibility for unpaired lots	Set the eligibility points associated with bids for unpaired spectrum to account for the lot(s) with restricted usage rights: • the eligibility associated with n unpaired contiguous lots is n-1; and • the eligibility associated with n unpaired lots in two contiguous blocks (in a split bid) is n-2.
Switching	No restrictions on switching between categories of lot
Price ratios	No defined linkage between clock prices for lots in the 2.6 GHz band and the 2010 MHz lot.
Activity rule	Retain a quantity-based activity rule rather than adopt a value-based activity (relaxed revealed preference rule)
Pricing algorithms and winner determination	In calculating the opportunity cost for a winning Assignment Stage bid, the winner's assignment bids are set to zero in the modified winner determination. “Modified assignment bids” must be greater than or equal to 0 in the Assignment Stage.
Deposits and bidder default	Set deposits in the Principal Stage to no more than 50% of a bidder’s highest bid value, with refinements to the rules and penalties for bidder default.

	Deposits for participation in the Assignment Stage remain at 100%.
Rounds per day/speed of price increases	No restriction that the number of primary bid rounds is limited to one per day in the later stages.

7.83 We received 10 responses to the Auction Rules Consultation which provided further views on our detailed proposals for which we are grateful. In the case of the following four issues, respondents were either supportive or made no comment, and we will therefore proceed with the position set out in the Auction Rules Consultation:

- we will define the eligibility points associated with bids for unpaired spectrum as set out in the table above;
- we will not introduce a link between 2010 MHz and 2.6 GHz clock prices;
- we will not change to a value-based activity rule; and
- we will not restrict the number of primary bids rounds to one per day.

7.84 We received a more diverse set of comments in response to the remaining proposed changes listed in the table above, as well as responses to the open questions on the updated detailed auction rules and draft regulations as contained in Annexes 6 and 7 respectively of the Auction Rules Consultation. In the remainder of this sub-section, we discuss and present final conclusions on each of these points. We also discuss other issues raised by respondents relating to auction procedures which were not specifically covered in previous consultation documents. Finally, we provide a clarification regarding the assignment options that will be made available to winning bidders in the Assignment Stage.

Auction information policy

7.85 The Auction Rules Consultation included the proposal that we release to bidders, at the end of each primary round, information on bids made on an anonymised basis. One respondent felt that we should go a step further and apply a consistent set of bidder labels from round to round with respect to the individual bids made. They argued that providing this additional round by round information would enhance price discovery and reduce common value uncertainty for participants without unnecessarily exposing the process to an increased risk of collusion.

7.86 Since the publication of the Auction Rules Consultation we have undertaken further analysis on the most appropriate level of information to be released at various stages of the auction and received specialist advice on the issue. On the basis of this further analysis we have decided to restrict the amount of information available to the level of aggregate demand for each category of lot, as initially proposed in the December 2006 Consultation.

7.87 The reason for this decision is that we have identified a number of scenarios in which the provision of even limited amounts of additional information (such as the identities of remaining active bidders, or the size of the largest bids, expressed in terms of the number of lots included in the largest bid for each category of lots) create risks by facilitating strategic bidding behaviours which would undermine the efficiency of the auction process.

7.88 The countervailing consideration is that the provision of information might help to reduce common value uncertainty over factors such as future levels of consumer demand for data services, the capabilities of emerging technologies etc, all of which are reflected in the value that other bidders place on the spectrum. The most important information to have in this context is the aggregate demand in each category of lot in each round. With this information, bidders can observe the reduction in demand as prices rise between primary rounds and so learn progressively more about the aggregate bidder valuation curve. It is possible that additional information on individual bids or bidders could provide further assistance. But this is likely to be of limited incremental value in reducing this type of common value uncertainty.

7.89 Additional information on individual bids or bidders is likely to be more beneficial in reducing that aspect of valuation uncertainty which is linked to the impact of award outcome on the future competitive landscape (although even here, the information might still have limited value[124]). However, the kind of information that will help bidders reduce this aspect of valuation uncertainty is, not surprisingly, the same kind of information that can facilitate strategic bidding behaviour that is intended to influence the competitive landscape that emerges from the auction.

7.90 As regards the other proposals that we put forward on information policy, we have decided to:

- announce publicly the base prices to be paid by each winner at the end of the Principal Stage;
- provide bidders with information on all possible permutations of how the winning bids at the end of the Principal Stage can be accommodated in the 2.6 GHz band; and
- publish summary auction information at suitable intervals (e.g. at the end of each bidding day).

7.91 Both full transparency and release of anonymised bid information increase the risk of strategic behaviour, such as modification of bids to reduce the chances of other specific bids winning. Information about others' willingness to pay for spectrum relevant to the reduction of common value uncertainty is in any case largely revealed through information about aggregated demand. We judge that revealing more detailed information would not produce a further reduction in common value uncertainty sufficient to justify the risk of strategic behaviour. We have therefore decided to release to bidders the level of demand per category of lots but no additional information about bids made during the primary bid rounds.

Offering more bid options

7.92 One respondent argued that some bidders may attach different valuations to the relative position of the two portions of a split bid and suggested a solution which they felt would enable bidders to express the different valuations. They suggested that bidders who wished to submit an additional supplementary bid should be able to submit valid additional supplementary bids on both possible permutations of their

[124] The actual outcome of the Principal Stage depends not only on the primary round bids, on which information can be made available, but also on the supplementary bids made in a single sealed bid round. In some circumstances the supplementary bids can play an important role in determining the outcome of the Principal Stage.

specified split ratio (e.g. on both 50:30 and on 30:50 where these numbers represent the MHz of spectrum in the lower part and upper part of the 2.6 GHz band respectively).

7.93 In the Auction Rules Consultation, one of our arguments against allowing bidders to specify the location of each part of a split bid was the extra probability of unsold lots that this created. The stakeholder's suggested amendment would negate this particular problem. However, the suggested amendment does not deal with the main argument that we presented. If we were to allow a bidder to effectively specify the location (lower or upper unpaired area) of each part of a split bid, it would be inconsistent for us not to also allow a bidder to specify the location of an unsplit bid. As outlined in the Auction Rules Consultation, this would require the creation of two types of unpaired lot resulting in complications to the primary bid rounds as well as the supplementary bids round. In addition, it would no longer be easy to define a meaningful concept of "aggregate demand for spectrum in the 2.6 GHz band" during the primary bid rounds.

7.94 We understand that implementing the requested change could provide some measure of benefit to certain bidders who, for various reasons, place different values on different permutations of split bids. However, we believe that any benefits would be minor and are significantly outweighed by the disbenefits associated with the extra complexity that this change would introduce. In view of this, we have not made changes to the auction rules to allow bidders to make supplementary bids reflecting different values for different permutations of split bids.

7.95 One respondent expressed concerns about the inclusion of the 5 MHz boundary block between paired and unpaired spectrum in the auction and presented a scenario where, it believed, two bidders who had won unpaired spectrum in the Principal Stage would then seek to outbid each other in the Assignment Stage to avoid receiving this block.

7.96 This concern represents a misunderstanding of the auction process and the scenario presented will not occur. In fact, when there are both paired and unpaired lots in the winning combination of bids at the end of the Principal Stage, the block between unpaired spectrum and paired downlink spectrum (block 24) will be added to the assignment of the winner of unpaired spectrum who wins block 23. Block 24 is therefore simply assigned to this winner and is not counted as one of the lots won by this bidder in the Principal Stage. Meanwhile, a Principal Stage bid for unpaired lots includes one or two restricted blocks:

a) bids for unpaired lots that are primary round bids or standard supplementary bids are for a single contiguous range of frequency blocks. The lowest of those blocks is a restricted unpaired block.

b) bids for unpaired lots that are additional supplementary bids are for two contiguous ranges of frequency blocks. The lowest block of each of those ranges is a restricted unpaired block.

7.97 Therefore, when making either type of Principal Stage bid, a bidder will know clearly how many restricted and standard unpaired blocks are included in that bid.

Switching and the 2010 MHz lot

7.98 One respondent commented that demand for the 2010 MHz band is likely to be different to that for the 2.6 GHz band, and therefore the prices for each band are

likely to be different. The respondent thought that this may result in strategic behaviour, with some bidders using the 2010 MHz band to park eligibility. They suggested that a way to mitigate this risk would be to make the eligibility rights for the 2010 MHz band non-exchangeable with rights for the 2.6 GHz band (except if there were no bids at all on the 2010 MHz band during the first primary bid round in which case the eligibility rights could revert to being exchangeable).

7.99 We recognise that the ability to switch between the 2010 lot and the 2.6 GHz lots creates the potential for bidders to park their eligibility on the 2010 MHz lot at some point during the primary bid rounds, at least in situations where the clock price of the 2010 MHz lot is below the equivalent clock price for 2.6 GHz lots. However, since all valid bids are used in the winner determination calculation, any bidder who does not actually wish to win the 2010 MHz band and engages in such a strategy would run the risk of winning the lot and having to pay for it. Moreover, supplementary bids should be for packages which contain only those lots that a bidder actually wishes to win; and since higher bid values are required on these supplementary bids (than on any primary round bids for the same package) this further reduces the chance of bidders that don't want the 2010 lot actually winning it. Indeed, in the trial auctions we have run, the results were robust to bidders parking their eligibility on the 2010 lot (in that the bidder who won the 2010 lot was always the bidder who placed greatest value on the lot, even when it had had to drop out of the bidding because of the effects of other bidders parking their eligibility on the 2010 lot). In consequence, we consider that there is a low risk of the auction outcome being inefficient as a result of an incentive to park eligibility.

7.100 On the other hand, and as first set out in the December 2006 Consultation we believe that there is some degree of substitutability and complementarity between the 2010 MHz band and unpaired spectrum in the 2.6 GHz band. For example, bidders may be able to deploy similar applications in both bands and the 2010 MHz band could be used to provide additional capacity in high demand scenarios. Preventing switching could therefore create substitution and aggregation risks.

7.101 While recognising that a small element of risk remains, we believe that the substitution and aggregation risks associated with de-linking eligibility for the 2010 MHz band are greater than the risks of allowing switching. Therefore, we do not intend to remove the ability to switch between 2010 MHz and 2.6 GHz lots.

Pricing algorithms

7.102 Several respondents had concerns on the complexity of the algorithms and asked that we do more to help bidders understand the process. One respondent noted that we had made available the award software used to determine winners and prices for the award of the 10-40 GHz band and asked that we do the same for this award. Another respondent asked that we go a step further and provide a full algebraic description of the computational tool with which we intend to calculate the base prices as well as worked examples with a clear description so that bidders can understand how the rules will work in practice.

7.103 We intend to make available the software that will be used for calculating the winners and the prices they will pay in this award. This will allow interested parties the opportunity to construct their own worked examples to understand how the rules will work in practice.

Deposits and bidder default

7.104 One respondent thought that Ofcom should not leave lots unsold in case of default by a winner of the Principal Stage, but should consider accepting valid bids from other bidders who, prior to the default, do not have a winning bid.

7.105 We accept that it would be desirable to be able to award all the spectrum as part of this auction process in order to enable the use of valuable spectrum at the earliest possible date, and to avoid the costs of a further process to release the unsold spectrum. We considered one way of dealing with this problem in the Auction Rules Consultation, i.e. to exclude all the bids of the bidder who has defaulted on its base price payment and then re-calculate the auction result. However, we found that re-calculation of the auction result had several undesirable features:

- it could become very complicated to introduce additional restrictions into the specification of the winner determination and pricing algorithms so as to capture a set of "no worse off" requirements in order to avoid bidders who were successful before the default then being awarded a package that they found less desirable; and

- it could, under certain circumstances, create an incentive for a bidder to default deliberately where this has, for example, the effect of denying a rival bidder from receiving spectrum that they would otherwise have won.

7.106 The suggestion here may in theory be simpler than re-calculating all of the auction results. However, it would also result in some undesirable features. Simply accepting bids from bidders who, at that point, do not have a winning bid could potentially result in spectrum not being won by the bidder who valued it most. It is likely that the combination of bids made up of the winning bids at the time of default (minus the defaulted bidders bid) plus the bids used to fill the gap would not be the combination of bids of highest value. In addition, in a similar way to recalculation of the auction, adoption of this proposal could create incentives for bidders to default deliberately as they could change the outcome of the auction by doing so.

7.107 In view of the difficulties involved with recalculation and other approaches to resolving unsold lot issues resulting from default, we do not intend to make changes to the arrangements for dealing with the consequences of default as set out in the Auction Rules Consultation. We believe that the approach as it stands provides a strong disincentive to default. Even where the deposit level is set well below 100%, default is likely to be very expensive. Given the low likelihood of default in these circumstances we consider the approach that we propose to be appropriate.

7.108 Several other issues were raised by respondents in relation to deposits and bidder default. One respondent was concerned about the potential for accidental default and proposed that Ofcom consider using the auction bid software (or another secure method) to provide positive confirmation or warnings back to bidders that their deposit has or has not been received. Several respondents requested that Ofcom refund interest accrued on deposits while in Ofcom's account, especially in view of the potentially high amounts of deposits likely to be required. Finally, a respondent requested that Ofcom provide bidders with two business days' notice of the deadlines for deposits.

7.109 The following points summarise our responses on these issues:

- *Accidental default* - The process for payment of deposits runs independently of the award software and there is no functionality which would allow us to automatically inform bidders of the receipt of monies. It is up to bidders to take the necessary steps to ensure that monies are received by Ofcom by the specified deadlines. However, we would expect to follow a similar approach to that which we adopted for the 10-40 GHz auction in which we checked the status of deposit receipts at midday on the day that deposits were due, with a view to notifying bidders if we had not received their deposit payment by that time. In light of feedback on the 10-40 GHz award, we will consider extending this process so as to inform all bidders of our information on the status of their deposit receipt.

- *Interest refunds* - As set out in the Auction Rules Consultation, we have already undertaken indicative analysis on the amount of interest likely to be received and this suggests that the amount earned is likely to be less than the costs that Ofcom will have incurred in preparing and running this award. Additionally, we do not intend to charge any administration fee for participation in the award. Therefore we do not intend to return interest accrued from deposits.

- *Timing of deposits* – The notice periods for deposit deadlines are set out in the Information Memorandum. In some cases, the notice periods given may be less than two business days. However, we believe the length of the notice periods that we have decided on gives bidders sufficient time within which to prepare to pay the extra amount whilst still allowing the auction to be run at a reasonable pace.

Other issues raised by respondents

7.110 In the Auction Rules Consultation, question 12 asked for comments on the updated detailed auction rules and procedures for the 2.6 GHz and 2010 MHz award as contained in Annex 6 of the document. In response to this question, one respondent asked for clarification of what would happen in the event that a bidder with extensions left fails to submit a bid after the 30 minute extension period. The answer is that a bid will not be accepted after the 30 minute extension period has expired and the bidder's eligibility limit for the next primary bid round would fall to zero. Although bidders have the right to two extensions during the primary bid rounds, they are not permitted to exercise both extension rights in the same primary bid round.

7.111 In question 13 of the Auction Rules Consultation, we asked for comments on the draft regulations contained in Annex 7 of the document. One respondent commented that the regulations should be as explicit as possible regarding all aspects of the auction process including, for example, the delays and notice periods between stages. They proposed that regulation 35 be amended to reflect Ofcom's proposals on information policy and that the auction rules and procedures be fully reflected in the regulations.

7.112 In the Draft Auction Regulations published in parallel with this Statement, Regulation 36 describes the release of information that will be made during the Principal Stage of the auction based on Ofcom's updated proposals outlined earlier in this section.

7.113 For certain procedures, it is appropriate for Ofcom to retain a measure of discretion over timing in order to take into account variables in the way the auction process unfolds. The draft regulations capture the areas of the auction rules and procedures for which we need to retain this discretion. The Information Memorandum provides additional details and guidance on the way we are likely to approach these decisions and we plan to publish more detailed guidance on scheduling before the bidding commences.

7.114 One respondent was concerned that the second price rule used to decide the price paid by winning bidders is subject to strategic manipulation.

7.115 The second price rule that we will use in this auction produces a unique price for each winner. Also, in our testing of the auction design, we have not discovered any opportunities for strategic manipulation which are specifically related to the second price rule. The example of strategic behaviour in relation to prices that the respondent provided assumes that bidders would not bid their true value in the hope of paying less and still winning. Bidders acting in this way would expose themselves to the risk of not winning and this is the type of irrational behaviour that the second price rule is designed to address. We do not think that the arguments raised by the respondent in their response to the December 2006 Consultation are valid in respect of the final rules set out in the Information Memorandum and the Draft Auction Regulations.

7.116 Another respondent requested that we provide short term "validation access" to the "auction server" for qualified bidders between the notification of qualification and the start of bidding so as to be able to ensure functioning of the communications links, client software and hardware to prevent or minimise delay to the start of bidding due to IT problems. We did this for the 10-40 GHz auction and plan to do so again for this auction. They also requested that we consider putting a secondary check on the "submit button" on the bid software in order to minimise or prevent "accidental" submissions. Ofcom intends to use similar software to that used for the 10-40 GHz auction. This features a two-step process to 'check' and then 'submit' bids.

7.117 Finally, one respondent noted that they had identified a number of bidding strategies that, if adopted would lead to unsold paired lots at the end of the auction. They thought that this could create significant pricing uncertainty during the Assignment Stage of the auction but that this could be mitigated to some degree if Ofcom provided further details about the potential future re-award of unsold paired lots in the Information Memorandum.

7.118 It is possible that some lots will remain unsold at the end of the auction. However, the auction has been designed in such a way as to minimise the risk that lots are unsold due to flaws in the auction design or as result of strategic behaviour. Also, we do not believe that it is appropriate for us to decide in advance on the most appropriate method for subsequent release of any unsold lots. There would be several options open to us as to the timing and method of release of unsold lots and our decision on these would need to be taken at the time, based on the prevailing circumstances following the completion of the initial award process.

Clarification regarding assignment options available to winning bidders in the Assignment Stage

7.119 Since the publication of the Auction Rules Consultation, we have reviewed the way in which the potential Assignment Stage outcomes are defined as part of our general review of the draft regulations for the award. In particular, we have finalised our assessment of how unsold lots should be handled for these purposes.

7.120 There are two circumstances for which we are clarifying the effect of unsold lots on the options for assignment:

a) where the winning combination of Principal Stage bids includes both paired lots and unpaired lots as well as unsold lots in the 2.6 GHz band; and

b) where the winning combination of Principal Stage bids includes unpaired lots only, but not all 38 lots were sold (noting that where no paired lots are won then all 38 frequency blocks in the 2.6 GHz band are available for award as unpaired lots).

7.121 In the first case, we will make available to bidders for unpaired lots all assignment options that are consistent with an approach in which the unsold lots are grouped into two contiguous blocks, one positioned immediately above the paired assignments in the lower part of the band, and, if relevant, the other positioned immediately above the paired assignments in the upper part of the band. In doing this, we will not constrain the relative sizes of the two blocks of unsold spectrum (e.g. if there are 3 unsold lots then in principle these could be partitioned as 3:0, 2:1, 1:2 and 0:3).

7.122 In the second case, we will make available to bidders for unpaired lots all assignment options that are consistent with an approach in which the unsold lots are grouped into one contiguous block. This contiguous block of unsold spectrum is treated as if it were another winning bidder for the purposes of deriving feasible assignment options. Moreover, lot 24 is available for inclusion within a winning bidder's assignment option (rather than being withheld and awarded to the bidder that is assigned lot 23 as happens when paired lots are won in the Principal Stage).

7.123 The consequences of these rules are illustrated with examples in the Information Memorandum.

Summary of changes to the auction rules and procedures from those contained in the Auction Rules Consultation

7.124 Based on the analysis set out above, we have decided to make one substantive change to the auction rules and procedures set out in the Auction Rules Consultation. This change relates to the auction information policy. As set out in paragraph 7.91, we have decided to make available only the aggregated level of demand for each category of lot at the end of each primary round and not to make available any information of individual bids or bidders. This change is reflected in the Draft Auction Regulations and Information Memorandum published in parallel with this Statement.

7.125 In addition, we have clarified the way that unsold lots influence the assignment options that are made available to bidders in the Assignment Stage.

Section 8

Conditions relating to individual bidders

8.1 Our prior consultations on the award of the 2.6 GHz and 2010 MHz bands discussed a number of issues which are relevant to spectrum access, and individual bidders in particular, in addition to those relating to auction design, technical licence conditions and non-technical licence conditions.

8.2 This section explains our decisions in these areas and sets out our thinking behind reaching these decisions, taking into account relevant feedback from stakeholders in response to the proposals contained in the December 2006 Consultation, the Discussion Document and the Auction Rules Consultation.

Table 9: Summary of decisions regarding conditions relating to individual bidders

Area	*Decision*
Competition issues and BT's participation	We are not imposing restrictions on the conditions of participation in the award on any potential participant or group of participants in particular. All applicants will be subject to the same rules and we are not preventing any party from qualifying on the basis of their position in any downstream market.
Use of a spectrum cap or condition to prevent inefficient hoarding	A spectrum cap that is equivalent to 80 MHz of standard spectrum (normal base station powers) in the 2.6 GHz band (i.e. up to 90 MHz in the case of a split, unpaired assignment that contains two restricted lots) will apply to all bidders in the auction. The spectrum cap will not apply to the secondary market.
Association between applicants and consortia in the award	An entity that holds a material interest in several applicants will be able to apply to be excluded from the relevant applicant or bidder groups under certain conditions designed to safeguard the integrity of auction process so as to comply with the requirement that an entity cannot be an associate of more than one bidder group. Ofcom retains discretion in deciding whether an associate can be excluded from a bidder group under this procedure.

Restrictions on the participation of specific organisations or group of organisations

8.3 Consistent with our objectives for the award, including the promotion of competition and the optimal use of the spectrum, we have considered whether we should impose restrictions on participation in the award. This sub-section explains how we have come to our decision that no restrictions or conditions should be placed on the participation in the award of any specific organisations or group of organisations, including BT. This section is structured in the following way.

- We set out the reasons for our initial view that no restrictions or conditions should be placed on BT in its participation in the award as proposed in the December 2006 Consultation and the Discussion Document.

- We consider the issues raised by stakeholders in response to the December 2006 Consultation, the Discussion Document and the Auction Rules Consultation.

- We summarise our conclusions and the reasons for our decision.

Position set out in Discussion Document that there is no case for imposing restrictions on BT's participation in the award

8.4 In the Discussion Document (at paragraphs 6.3 to 6.21), we argued that there did not appear to be any case for imposing accounting separation rules on BT in respect of this award. We said that the undertakings given by BT pursuant to the Enterprise Act 2002, following Ofcom's Strategic Review of Telecommunications, should be sufficient to ensure that any other operator could gain access to fixed network services (in which BT is dominant). We also said that the probability that BT could foreclose competition in mobile broadband services (the likely key service in this award) appeared low - other operators would have the opportunity to bid for spectrum and offer mobile broadband in competition with BT.

8.5 Moreover, we noted that the undertakings were also intended to allow any operator to replicate any retail service provided by BT that was dependent on certain wholesale inputs (in the provision of which BT is dominant). This, together with existing competition law provisions, should be sufficient to rule out any scope for BT to bundle fixed with mobile retail services in a manner which raises competition concerns.

8.6 We also pointed out the significant changes in fixed retail markets since 1999 when accounting separation of BT's mobile activities was raised in the Information Memorandum for the 3G auction. Since 1999, BT's dominance in several key markets has fallen considerably, due to changes in the regulation of fixed telephony such as wholesale line rental and carrier pre-selection which have led to greater competition.

Responses to our proposals

8.7 A confidential response to the December 2006 Consultation proposed that there should be accounting separation restrictions on BT, between its mobile and other services if it won spectrum in the award. The confidential response referred to a provision in the Information Memorandum for the 3G auction published in 1999, which implied that accounting separation should have been applied to BT if it won spectrum in the auction. The confidential response argued that not imposing restrictions would result in a risk of anti-competitive behaviour, e.g. BT providing fixed network services on preferential terms to its mobile business or BT bundling fixed retail services with mobile retail services. T-Mobile also raised concerns that BT's unfettered entry into the market could have an adverse impact on competition.

8.8 The stakeholder who submitted the confidential response expressed similar views in response to the Discussion Document and the Auction Rules Consultation. It disagreed with Ofcom's position set out in the Discussion Document. It said that the important issue was whether there had been any substantial changes since 1999 in BT's position in the markets from which it could potentially leverage its position, i.e.

fixed network and retail services. It argued that the level of competition in fixed and mobile broadband services was not relevant.

Conclusions

8.9 Taking into account the responses received to out consultations, we remain of the view that there is no case for imposing restrictions on the participation of any specific organisation or group of organisations in this award. In particular, for the same reasons given in response to the Discussion Document, our view is that it would not be appropriate to restrict BT's participation in the award or to impose additional conditions on BT as a function of participating. To reiterate, there have been substantial changes in both the market and the regulatory conditions concerning the provision of fixed network and retail services by BT. We do not consider that respondents have raised any arguments to suggest that the undertakings given by BT should not be sufficient to address the potential for any anti-competitive leveraging of BT's position in fixed network services.

8.10 Moreover, there have been substantial changes in the fixed retail markets in which BT competes, as highlighted in the Discussion Document. BT's market share in many fixed retail markets has fallen considerably. This significantly reduces its ability to leverage market power anti-competitively into mobile retail services by bundling with fixed retail services. More generally, we have not identified any risk of market failure that would justify restrictions on the participation of any specific organisation or group of organisations in this award. On the contrary, introducing any such restriction would risk harming participation and reducing the scope for competition and innovation.

Use of a spectrum cap or a condition to prevent inefficient hoarding of spectrum

8.11 This part of Section 8 considers the issues relating to the application of a spectrum cap.

Summary of discussion in the December 2006 Consultation and the Discussion Document

8.12 In the December 2006 Consultation, we proposed the use of a spectrum cap on the amount of spectrum which any one bidder could acquire in the auction. We suggested setting this level at 90 MHz which was felt at that time to be comfortably higher than the largest individual requirement of which we were aware.

8.13 In proposing this spectrum cap, we had considered whether there was a case for reserving spectrum for particular technologies, or for ensuring a minimum number of players in relevant downstream markets. We considered that the market would be likely to be a better judge both of which technologies would best promote innovation and consumers' interests, as well as of what the efficient number of firms in the relevant downstream markets would be.

8.14 Furthermore, in the December 2006 Consultation we considered that it would be unwarranted for us to try to determine the optimal assignment of spectrum to an individual user given the uncertainties over potential uses of the spectrum and user requirements. However, we felt that there was a small chance that one party could win a large amount of the available spectrum which could limit the scope for competition in the provision of innovative services. Accordingly, we proposed the 90 MHz cap as a safeguard against this eventuality.

8.15 The vast majority of responses to the December 2006 Consultation were in agreement with the proposals laid out therein, with comments on the spectrum cap falling into three categories:

- the size of the spectrum cap;
- the extension (or not) of the cap to the secondary market; and
- the inclusion of a 'use it or lose it' condition in the licences as an additional measure to prevent inefficient hoarding of spectrum

8.16 Paragraphs 6.31–6.34 of the Discussion Document contained our consideration of the size of the spectrum cap. Our conclusion at that time was that 90 MHz was appropriate as it would be:

- large enough not to preclude any plausible business case for use of the spectrum;[125] and
- low enough to prevent the (low) risk of foreclosure in markets that could be served by users of this spectrum.

8.17 Considering the extension of the spectrum cap to the secondary market, our analysis in Paragraphs 6.35–6.37 of the Discussion Document explained our view at the time that the cap should not apply to the secondary market (i.e. should not extend beyond the completion of the auction process and the award of licences).

8.18 In arriving at this view, we considered the balance between consistency in the short term with the auction design (which suggests that the cap should continue to apply) and potential changes to spectrum requirements reflecting changes in business models or technology (which suggest that the cap should not continue to apply). We further considered that any restriction on trading in the secondary market could be circumvented by one firm acquiring another if the entity holding the spectrum licence is a separate company. On balance, we proposed that the spectrum cap should not be applied to the secondary market as we felt that this would add little incremental benefit in achieving our objectives for the award and was also consistent with our duty to take the least interventionist approach to achieving our objectives.

8.19 Finally, in Paragraphs 6.38–6.52 of the Discussion Document, we considered the potential inclusion of an additional condition to prevent inefficient hoarding of spectrum. In particular, we considered whether it would be appropriate for us to retain the power to revoke the licences to be awarded in the circumstances where there was inefficient hoarding of the spectrum, even if this was within the initial 20 year period.

8.20 Our conclusion at that time was that it was not appropriate to include any additional conditions to prevent inefficient hoarding as it could increase the perception of regulatory risk among potential bidders (notably the MNOs who may wish to hold the spectrum in reserve until such time as LTE technology is commercially available) which may lessen the efficiency of the auction, and may even reduce the ability of bidders to raise capital and participate in the award.

[125] The largest individual requirement we were aware of at the time of the Discussion Document was 60 MHz, and it was felt that 90 MHz represented a sufficiently large margin over and above this figure.

Changes to spectrum cap proposed in the Auction Rules Consultation

8.21 In general, responses to the Discussion Document were supportive of the inclusion of a spectrum cap, the value proposed in the Discussion Document and the proposal not to include an additional condition to address the risk of inefficient hoarding.

8.22 With regards to the spectrum cap and implications for the auction rules and procedures, one respondent suggested that the spectrum cap as defined in the Discussion Document could lead to bidders being restricted in their ability to freely switch between paired and unpaired lots during the Principal Stage of the auction. The stakeholder suggested that the spectrum cap should not include restricted unpaired blocks so that bidders for unpaired spectrum would effectively be able to bid for the same amount as for paired.

8.23 In light of this, Paragraphs 3.31-3.36 of the Auction Rules Consultation set out proposed changes to the treatment of eligibility for unpaired lots and, based on this change, we proposed revisions to the spectrum cap so it would be equivalent to 16 eligibility points corresponding to:

- 90 MHz of unpaired spectrum for bids including split unpaired spectrum;
- 85 MHz of unpaired spectrum for bids including contiguous unpaired spectrum;
- 80 MHz of paired spectrum for bids including only paired spectrum; or
- equivalent combinations of paired and unpaired lots.

8.24 For clarity, this proposal has the effect of reducing the cap on standard blocks of spectrum in the 2.6 GHz band from 90 MHz to 80 MHz. Our opinion at the time of the Auction Rules Consultation was that this value would still provide an ample margin of security over the largest plausible business case of which we were aware (60 MHz).

8.25 We also considered the suggestion by one respondent to the Discussion Document that bidders be allowed to obtain enough spectrum to run two separate networks, each of 60 MHz giving a total of 120 MHz. Our view at the time of the Auction Rules Consultation was that this was not a desirable outcome.

8.26 Four respondents provided comments on spectrum caps in their responses to the Auction Rules Consultation. Two of these accepted our proposed amendment to the spectrum cap of 80 MHz excluding restricted use channels (though one reiterated its reservations about the principle of using a spectrum cap). The other two repeated brief comments made in their previous responses, both agreeing with the principle of the spectrum cap, but one suggesting a cap of 90 MHz and the other suggesting a cap of 60 MHz (although neither produced substantive arguments for why they felt that their proposed limit was appropriate)..

8.27 None of the responses to the Auction Rules Consultation provided any new evidence which has caused to change our view that 80 MHz of standard spectrum is a suitable limit at which to set the cap.

Other related issues raised in responses

8.28 Responses to the Discussion Document raised three other issues which relate to the question of the spectrum cap:

- a suggestion that existing spectrum holders with unused or partially unused spectrum which would compete with the 2.6 GHz and 2010 MHz bands should be restricted in how much spectrum they could acquire, preferably through a lower spectrum cap;

- a concern that a spectrum cap of 90 MHz may allow a small number of TDD bidders to 'corner' the market which could have an impact on the secondary market; and

- a suggestion that the proposed spectrum cap was inconsistent with our general approach to the auction and that a cap of 25% of the spectrum available under the award (45 MHz) would be consistent with an analysis of significant market power.

8.29 On the first of these comments, we do not feel that the inclusion of such a condition is necessary and it would create a risk of regulatory failure. It would be difficult for us accurately to assess whether existing spectrum holders are not using, or are only partially using, spectrum which may compete with the available bands. For example, we would not be privy to such a bidder's strategy for the use of its existing network. Additionally, there may be valid commercial and technical reasons for a bidder wishing to acquire spectrum in the 2.6 GHz band while partially using other spectrum holdings which could compete with the 2.6 GHz and 2010 MHz bands and this will be reflected in their valuation of the available spectrum.

8.30 On the concern that a small number of TDD bidders could corner the market, we note that the auction is designed to promote competition and offers bidders a fair chance of winning spectrum based on their valuations. Moreover, we have not identified any risk of market failure in the downstream retail markets which would justify imposing a minimum number of licensees in addition to the spectrum cap that we are implementing.

8.31 Finally, in relation to the suggested spectrum cap of 25% of the spectrum available under the award, our view is that significant market power is unlikely to arise in itself with regard to holding a licence for the spectrum. There is therefore no need to set a spectrum cap to guard against this eventuality. The spectrum to be awarded is an input, potentially, to service providers who could operate in a number of markets. For each of these potential markets, a variety of other spectrum is likely to be available. We therefore consider that holding 2.6 GHz spectrum up to the spectrum cap is unlikely to confer any degree of market power over the supply of spectrum itself.

Conclusion

8.32 In light of the above considerations and taking account of responses to our consultations, the auction will adopt a spectrum cap that is equivalent to 80 MHz of standard spectrum (normal base station powers) in the 2.6 GHz band. This is equivalent to 16 eligibility points (see Section 7 and the Information Memorandum) corresponding to:

- 90 MHz of unpaired spectrum for bids including split unpaired spectrum;

- 85 MHz of unpaired spectrum for bids including contiguous unpaired spectrum;

- 80 MHz of paired spectrum for bids including only paired spectrum; or

- equivalent combinations of paired and unpaired lots.

8.33 The auction design will allow bidders to switch between the 2010 MHz lot and lots within the 2.6 GHz band. Any bid must be for a package of lots which does not exceed 16 eligibility points. Accordingly, a package bid which includes the 2010 MHz lot, which corresponds to 2 eligibility points, can also include lots in the 2.6 GHz band that correspond to up to 14 eligibility points.

8.34 These restrictions will not apply following the award of the licences (i.e. subsequent trading of spectrum will not be subject to limits on the amount of spectrum in the 2.6 GHz and 2010 MHz bands any one organisation can hold).

Association between applicants and consortia in the award

8.35 This last part of Section 8 considers the issues relating to the association between applicants and consortia in the award. We provide a summary of the analysis set out in our various consultations and explain the decisions we have reached after taking account of comments raised in responses to our proposals during the consultation process.

Summary of discussion in the Discussion Document

8.36 The December 2006 Consultation proposed that there should be rules to prohibit collusion and bidder association which would be similar to those used in other spectrum awards. The December 2006 Consultation focussed on other issues surrounding the award of the 2.6 GHz and 2010 MHz bands and did not go into specific detail on the rules to be applied to the auction with regards to bidder association.

8.37 We expanded on this issue in the Discussion Document to provide an indication of the approach we would be likely to follow in placing restrictions on the links between participants in the proposed award, whilst recognising that interested parties might wish jointly to participate in the award and that investors may consider financing more than one potential bidder.

8.38 In the Discussion Document, we outlined the main objectives of these restrictions, i.e. to limit the scope for coordinated strategic behaviour between participants, to provide a clear framework for preventing the flow of confidential information between bidder groups and to avoid circumvention of the spectrum cap on the amount of spectrum any one bidder can win. Our objectives also included not unnecessarily restricting the ability of interested parties to participate legitimately in the auction.

8.39 We suggested that the approach would be likely to follow a similar line to that followed in past spectrum awards for which we made regulations.[126] At a high level, we summarised the provisions as providing:

i) restrictions on the flow of confidential information; and

[126] These can be found on the Office of Public Service Information's website. See www.opsi.gov.uk and for example:
- http://www.opsi.gov.uk/si/si2006/uksi_20060338_en.pdf for the regulations applicable to the award of spectrum at 1781.7/1880 MHz (Statutory Instrument 2006 No. 338);
- http://www.opsi.gov.uk/si/si2006/uksi_20061806_en.pdf for the regulations applicable to the award of spectrum at 412/424 MHz (Statutory Instrument 2006 No. 1806); and
- http://www.opsi.gov.uk/si/si2007/uksi_20070378_en.pdf for the regulations applicable to the award of spectrum at 1785-1805 MHz in Northern Ireland (Statutory Instrument 2007 No. 378, as amended).

ii) restrictions on the potential for one applicant (or bidder) to exert direct or indirect control over another applicant (or bidder).[127]

8.40 We provided a brief summary of the main provisions as follows.

a) To prevent the flow of confidential information between separate applicants or bidders, applicants and bidders are required to identify their "bidder group", i.e. those organisations or persons that have a material interest in them (by way of shareholding or rights to determine the conduct of their business) or to whom they have disclosed confidential information. Ofcom can then assess whether confidential information may have been passed between groups and investigate what the nature of that information may be. A provider of finance may be in receipt of confidential information from several applicants or bidders. However any transmission of such confidential information by a provider of finance to another group would be considered by Ofcom to be against the requirements relevant to qualification to become a bidder (including the scope for distortion of the award process) and activity rules designed to prevent coordinated behaviour.

b) For bidder groups, one of the tests used to determine whether an organisation or person has a material interest in an applicant or bidder is whether that organisation or person has any interest in shares carrying more than 25% of the votes entitled to be cast at a general meeting of the applicant or bidder.

c) There should be no overlap between bidder groups of the applicants and, if there are overlaps at time of application, then the period between application and Ofcom's determination on qualification should be used to address these overlaps.

8.41 At the time of the Discussion Document, we expected to use a similar framework for the award of the 2.6 GHz and 2010 MHz bands and invited comments from interested stakeholders on whether they considered that this framework could place significant constraints on the way they could participate in the award.

Changes to bidder association proposed in the Auction Rules Consultation

8.42 A small number of responses to the Discussion Document commented on our proposals for managing bidder association and the potential for collusion in this regard.

8.43 In particular, further clarity was requested on the exchange of information between bidders (for example, during potential national roaming negotiations between a MNO and another bidder in advance of or during the auction). Additionally, some respondents raised the issue of the difficulty in providing funding to a number of potential bidders under our typical association rules. In particular, those responses considered that the rules could have a negative impact on competition by limiting the ability of potential bidders to raise funding.

8.44 In response to the request for further clarity with reference to potential national roaming agreements, our proposals were not to make any specific exemptions relating to roaming agreements. We felt that, while it could be possible in principle for two parties to hold discussions on possible roaming agreements that could be struck post-award without breaching the activity rules set out in the Draft Auction Regulations, it is equally possible that discussions could lead to the exchange of

[127] The example regulations include definitions of a number of key concepts such as "confidential information", "bidder group" and "associate" of an applicant or bidder.

information between two potential applicants that would affect their decisions in relation to the award process in a way that could distort the outcome of the award process. We therefore considered that it was appropriate to review each case individually and the draft regulations contained provisions for us to receive and assess the necessary information as part of the award process (see regulations 8 and 72 to 74). We also reiterated that potential bidders should exercise caution in this regard (and others) both before and, very importantly, during the auction and that they should take their own advice as appropriate.

8.45 On the question of rules concerning bidder association and the potential for this to have a negative impact on competition, we proposed some revisions to the auction regulations.

8.46 We outlined the principles of these modifications which were to allow a person holding a material interest (i.e. an "associate" as defined the regulations) in several applicants or bidders to opt out of being a member of the respective bidder groups under certain conditions designed to safeguard the integrity of auction process. This would then allow them to remain a member of (at most) one bidder group without causing disqualification. We proposed that the opting-out associate would need to provide suitable undertakings, for example that:

a) it had not, and would not, receive any Confidential Information in respect of the bidder group(s) from which it was opting out;

b) none of its Directors or employees had taken or would take part in any discussions or activities relating to the bids of bidder group(s) from which it was opting out (including Board members absenting themselves from any relevant Board discussions etc.); and

c) it would ensure that all directors or employees that might have contact with the bidder group(s) from which it was opting out (in the course of business that was not related to the award) were aware of this requirement.

8.47 We also proposed requiring similar undertakings from the applicant or bidder from whose group the associate was opting out.

8.48 We noted that, under these revised rules, the requirement would remain that there could be no overlap between bidder groups (i.e. a person cannot be a member of two bidder groups). However, having opted out of some bidder groups, our proposals would allow a person to be part of one bidder group only while holding a material interest in other bidders (subject to the conditions summarised above).

Issues raised in responses to the Auction Rules Consultation

8.49 There was general support for the principles set out in the Auction Rules Consultation among those who commented on bidder association provisions and the proposed opt out process. However, some argued that Ofcom should be cautious in developing the precise rules regarding the opt out process and avoid situations where bidding vehicles were set up only for the purpose of exploiting the opt out process in the auction. One respondent also requested sufficient time to review the precise wording in the draft regulations when those are published.

8.50 One respondent considered that associates trying to opt out of an applicant group would necessarily hold some private information regarding that applicant and that this would create risks for the award process. The respondent also argued that if there

were common associates across a range of winning bidders, or if bidding behaviour of bidders with common associates inflated the prices paid during the process (even if these bidders do not end up with any spectrum), this would probably result in challenges to the auction outcome in the courts.

8.51 One respondent queried whether it would be possible for an organisation to provide advice to several applicants or bidders and whether some of the rules on bidder association or confidential information should be amended to allow for that possibility.

8.52 Finally, one respondent argued that Ofcom should provide more guidance on the issue of negotiation of roaming agreements between potential bidders and should exempt those discussions from restrictions on the exchange of confidential information.

8.53 We agree that the process needs to be designed carefully and, in trying not to unduly restrict participation in the award through restrictions on bidder association, we have been mindful of the need to prevent opportunities for applicants to put the efficiency and the integrity of the process at risk. Taking account of the comments received from stakeholders, we have developed our proposals and have structured them such that an associate may apply to be excluded from an applicant or bidder group (as defined in the Draft Auction Regulations) for the purposes of the award. However, we do not consider that allowing an associate to be excluded from an applicant or bidder group would necessarily enable that associate to hold confidential information about the applicant or bidder group from which it had been excluded while participating in another bidder group. We have specified the undertakings required from the associate and the corresponding applicant so that both the associate and applicant need to provide detailed representations, warranties and undertakings regarding their dealings with one another. The required undertakings are included at Schedules 4 and 5 of the Draft Auction Regulations.

8.54 We place restrictions on the type of relationship that can exist between an associate eligible to be excluded from an applicant or bidder group, and the applicant:

a) the associate must not hold, whether directly or indirectly, any interest (construed in accordance with section 820 to 825 of the Companies Act 2006) in any share which carries, or any shares which together carry, equal to or more than fifty per cent of the votes entitled to be cast at a general meeting of the applicant; and

b) the associate must not have the right to appoint or remove a majority of the applicant's board of directors.

8.55 We also require the associate and the applicant to warrant that they have not received any confidential information (as defined in the Draft Auction Regulations) relating to the applicant's bidder group as far as the associate is concerned and relating to another applicant as far the applicant is concerned, or to inform us of any reason why they may not be able to submit the warranty. We will assess any such reason when determining whether to grant the application to be excluded. However, if it were apparent to us that such a reason creates a material risk of distorting the outcome of the award process, then we would refuse the application to be excluded.

8.56 In addition, we require undertakings from both the associate and the applicant regarding the activities of their directors, employees and seconded employees to-

a) place restrictions preventing their involvement in-

- any discussions that relate to a potential bid of the applicant;
- any discussions of the board of directors of the applicant (following the application to be excluded) which relate to the applicant's participation in the award;
- any action the intent or effect of which are or would be to influence in any way the behaviour of the applicant or any member of its group in relation to any aspect of their participation in the award process;

b) ensure, when in the usual course of their employment they may come into contact with any employee or director of, or person seconded to the applicant or any member of the applicant's bidder group; that they are all aware of the undertakings given in connection with the application to be excluded from an applicant or bidder group.

8.57 We will consider very carefully any application to be excluded from an applicant or bidder group and request any further information which may be relevant to our decision as necessary. The exclusion mechanism is not an automatic procedure and all applications to be excluded from an applicant or bidder group are subject to approval by Ofcom.

8.58 The Information Memorandum includes some guidance in Section 4 on how we expect to consider applications for an associate to be excluded from an applicant or bidder group. By way of example, we are unlikely to consider favourably the case of an applicant incorporated shortly before the auction which has an associate applying to be excluded, or an applicant with an associate that has increased its participation shortly before the auction where the associate is also an applicant or is part of one or more joint-ventures that are applicants in the award. The exclusion mechanism is primarily designed for "passive" investors, who have been holding an interest in an applicant for some time but are not involved in the business of that applicant as it relates to the award and would like to participate in the award as part of another applicant group.

8.59 The deadline for associates and applicants to apply for an associate to be excluded from an applicant or bidder group will be the day on which Ofcom determines which applicants are qualified to bid in the award process. We anticipate that we will likely need at least 5 working days to consider applications to be excluded from an applicant or bidder group and therefore, we would note that applications made very shortly before this deadline may be rejected for lack of time, as we do not intend to delay the award process for this reason.

8.60 If two applicants have a common associate, they cannot qualify to bid in the award. Therefore, to avoid disqualification for both applicants, if Ofcom does not grant the common associate the right to be excluded from of one of the groups, then either the associate needs to change its position so as not to hold a material interest in at least one of the two applicants or one of the applicants needs to withdraw from the award process.

8.61 As regards the provision of advice relating to the award by one organisation to several applicants or bidders, our view is that it is possible, within the framework of the draft rules set out in December 2007, for one party to do so. They would be likely to have to take specific measures to ensure that no confidential information could flow from the persons advising applicants or bidders to others in the organisation. It is for interested parties to identify suitable provisions that suit their specific

circumstances. We are not therefore proposing to change the Draft Auction Regulations in relation to this issue.

8.62 In respect of roaming agreements, we remain of the view that it is possible for interested parties to engage on those issues and still qualify as separate applicants in the award process, but that in doing so, they should take specific provisions to avoid contravening the rules that relate to the exchange of confidential information and if necessary, seek their own independent legal advice in this regard. Any view on such discussions will be likely to depend on their specific circumstances and it is therefore appropriate and important for us to retain discretion in considering the position of applicants who have discussed roaming agreements for the purpose of qualification to bid in the auction. Any attempt to address this issue in detail in the Draft Auction Regulations would face significant risk of regulatory failure (such as preventing legitimate discussions) or of distortion to the auction (such as inadvertently allowing discussions that would have such an effect), given the wide range of discussions that could potentially take place.

Conclusion

8.63 In light of the above considerations we have decided to include provisions in the draft regulations for consultation, to the effect that an entity cannot be a member of more than one bidder group[128]. We propose that any entity that holds a material interest in several applicants or bidders will be able to apply to be excluded from the relevant bidder groups under certain conditions designed to safeguard the integrity of the auction process.

8.64 Any entity applying to be excluded from a bidder group would be required to provide a number of representations, warranties and undertakings, including that:

a) it has not, and will not, receive any Confidential Information in respect of the bidder group(s) from which it is to be excluded;

b) none of its Directors or employees has taken or will take part in any discussions / activities etc. relating to the bids of bidder group(s) from which it is to be excluded (including Board members absenting themselves from any relevant Board discussions etc.); and

c) it will ensure that all directors or employees that might have contact with the bidder(s) from whose bidder groups it is to be excluded (in the course of business that is not related to the award) are aware of this requirement.

8.65 If such an application is made, we will also ask the applicant from whose group the associate is to be excluded to provide corresponding representations, warranties and undertakings.

8.66 We will retain discretion in assessing each request to be excluded and we may not grant an authorisation to be excluded, in particular if we are satisfied that there is a risk that doing so would be likely to distort the outcome of the award process.

[128] See the Draft Auction Regulations for a definition of bidder group.

Section 9

Next steps

9.1 Alongside this Statement, we are publishing the following documents:

a) the notice of our proposals to make regulations;

b) the draft regulations which give effect to our policy decisions for the award including-

- the draft regulations that define the award process;
- the draft regulations that enable spectrum trading for the bands;
- the draft regulations that allow for publication of the identity of licensees and terms of the licences in the bands; and
- the draft order limiting the number of licences in the bands; and

c) the Information Memorandum which sets out relevant information to help parties interested in participating make their own decisions in respect of the award.

9.2 We are also serving notice of revocation on the remaining PMSE users in the 2.6 GHz band so that their licences for use of that band will be revoked on 31 August 2008, ahead of completion of the award.

9.3 The statutory consultation on our proposals to make regulations will end on 6 May 2008.

9.4 Before the closing date for responses, we expect to hold a seminar on our decisions for the award process and on the draft regulations. This will include a demonstration of the auction software and an invitation for interested parties to take part in a mock auction process after the seminar.

9.5 After the closing date for responses on the notice of our proposals to make regulations, we will analyse stakeholders' submissions and consider any amendments to the draft regulations which may be suitable. We will then make the regulations.

9.6 We also plan to make available on our website the software which we will use to determine who are the winning bidders and the prices to be paid by winning bidders so that interested parties can carry out their own test calculations. We expect to do so well before the start of the auction.

9.7 If further relevant information becomes available ahead of the start of the award process we will publish an update of the Information Memorandum, as necessary.

9.8 Interested parties should note that when we make the regulations for the award, the status of the award on our website will change from 'in preparation' to 'in progress'. In the spectrum awards section of our website at http://www.ofcom.org.uk/radiocomms/spectrumawards/, we will therefore move

information relevant to the 2.6 GHz and 2010 MHz award from http://www.ofcom.org.uk/radiocomms/spectrumawards/awardspending/ to http://www.ofcom.org.uk/radiocomms/spectrumawards/liveawards/. Similarly, after completion of the award process, the status of the award will change to 'completed' and we will move the information to http://www.ofcom.org.uk/radiocomms/spectrumawards/completedawards/.

9.9 The regulations will then come into force 3 weeks after they are made and we expect to start the award process by inviting applications at least two weeks after the entry into force of the regulations. We expect the application date to be in July.

9.10 Ofcom will notify applicants of the details of the membership of each applicant group so that they can identify any overlap in applicant groups and take actions as necessary. During the following weeks Ofcom will determine who the qualified bidders are, inform the qualified bidders and, after the last date for withdrawal, publish the names of the bidders. This timetable indicates that there may be a need for some communication with applicant groups during August.

9.11 On the basis that it is undesirable to start the bidding itself in August, we expect to commence the first round of bidding in September and complete the award by end of Q3 2008.

9.12 Table 10 below provides a summary of the next steps for the award following the publication of this Statement and associated documents.

Table 10: Summary of next steps for the award

6 May 2008	Closing date for responses to the notice of our proposals to make regulations
May/June 2008	Making of regulations Publication of a statement on the final regulations Provisional application date announced Mock auction(s) with interested parties
June/July 2008	Regulations come into force Application date announced
July 2008	Application date
August 2008	Potential progress on applications
September 2008	First bidding round (if there is more than one bidder)

Annex 1

Summary of responses and outline position

A1.1 This Annex sets out a summary of the responses to the December 2006 Consultation Document, Discussion Document and the Auction Rules Consultation, covering those areas where respondents suggested modifications to Ofcom's proposed approach. The summary also includes an outline of Ofcom's response to the points raised or cross-references to the relevant parts of the main body of this Statement. This Annex should be read in conjunction with the rest of this Statement, the December 2006 Consultation, the Discussion Document and the Auction Rules Consultation, where a number of these issues are discussed in more detail.

A1.2 35 respondents provided comments on the proposals set out in the December 2006 Consultation, 28 stakeholders responded to the Discussion Document and 10 stakeholders responded to the Auction Rules Consultation.

Responses

A1.3 Respondents to the consultations provided comments on nine broad areas:

1.3.1 views on pre-requisites to holding the award (such as decisions on other spectrum issues and European regulatory matters);

1.3.2 principle and timing of award (including demand);

1.3.3 non-technical licence conditions;

1.3.4 spectrum packaging (including potential for variation from the CEPT band plan);

1.3.5 auction design;

1.3.6 conditions relating to individual bidders;

1.3.7 technical issues and interference;

1.3.8 technical licence conditions (use of spectrum masks or spectrum usage rights (SURs)); and

1.3.9 other issues (including the 2012 Olympic Games).

Pre-requisites prior to holding the award

Issue raised	Comments	Ofcom's response
Linkages to other spectrum policy issues (e.g. 2G and 3G liberalisation)	*From responses to the December 2006 Consultation:* The BBC considered that Ofcom should provide clarity on its future plans for the 3.5 GHz band as an alternative for PMSE use. Ericsson, H3G, O2, Orange, Qualcomm, T-Mobile, the UMTS Forum and Vodafone all expressed an opinion that the issues of 2G and 3G liberalisation should be resolved before any auction of the 2.6 GHz band. Orange also requested further clarity on the potential for using spectrum released as part of the digital dividend review for mobile applications *From responses to the Discussion Document:* O2 and T-Mobile reiterated their requests for the issue of 3G liberalisation to be resolved before any auction of the 2.6 GHz band. Two confidential responses also supported this view.	In November 2007 we published a Statement on the variation of UK Broadband's licence in the 3.5 GHz band. PMSE currently has access to the 3.5 GHz band, which is managed by the Ministry of Defence, which is undergoing a review of how it uses spectrum as part of the Cave Audit. WRC-07 has designated the band as being suitable for mobile use in Europe. The MoD plans to publish a consultation on its plans in May 2008. We have set out our analysis of why the award of the 2.6 GHz band should not be delayed in Section 3. In December 2007 we published a Statement on the spectrum which will be freed up by digital television switchover. Please see that Statement, in particular the Next Steps section, as to our plans for this spectrum.
Linkage with European and other international regulatory discussions	*From responses to the December 2006 Consultation:* Arqiva, the BBC, H3G, O2, Orange and T-Mobile were of the opinion that any award should be delayed until relevant European regulatory decisions had been taken. Ericsson supported keeping the position on the 2.6 GHz and 2010 MHz bands under review in the light of possible developments in Europe even if this resulted in a delay to the award. The Nomad Forum supported an early award on the condition that Ofcom considered that a conflict with the potential RSC decision on WAPECS was unlikely. A confidential response considered that the award should proceed if a decision from the RSC on the 2.6 GHz and 2010 MHz bands was unlikely within the next 12 months. Otherwise, the response suggested that a delay to the process was suitable. BAA, BT, David Hall Systems, Intel, Siemens, Sprint Nextel and Vodafone considered that Ofcom should continue to monitor progress in Europe and inform on developments, but that this	We have been monitoring and participating actively in European and other international regulatory discussions. We have modified our approach to the award of 2.6 GHz in line with European developments (see, in particular, the adoption of block edge masks in accordance with CEPT proposals in the Auction Rules Consultation). Our decisions set out in this Statement are consistent with the Commission decision agreed by Member States at the RSC meeting on 2 April 2008, as discussed further in Sections 3 and 6.

	should not delay any award unless a clear direction which was contrary to Ofcom's proposals emerged (some of these respondents believed that it was unlikely that a conflicting decision would be made). *From responses to the Discussion Document:* O2 reiterated its position from its response to the December 2006 Consultation, that any award should be delayed until relevant European regulatory decisions had been taken. Two confidential responses also supported this view. T-Mobile stated that it was unconvinced that the current approach conformed to European harmonisation obligations. Ericsson stated that a departure from the CEPT band plan would be likely to lead to the UK being disadvantaged since it would be unable to access harmonised European-wide services. *From responses to the Auction Rules Consultation:* One respondent supported a binding decision on the 2.6 GHz band based on the output of SE42's work but considered that this should not affect the flexibility proposed by Ofcom or delay the award of the band. Another respondent supported Ofcom's changes to the proposed technical conditions ensure consistency with European discussions and urged Ofcom to continue to play a full role in European discussion. The respondent was not convinced that the RSC process would not result in a requirement to changes the proposed parameter.	
Claims of legitimate expectations of the 3G licence holders	*From responses to the December 2006 Consultation:* H3G argued that it had a legitimate expectation from the 1999 Information Memorandum for the 3G licence auction that the 2.6 GHz band would be available for use as a 3G expansion band (and, by implication, that it should not be made available until there was demand for its use in such a way). T-Mobile argued that it had legitimate expectations arising from the conduct of the Radiocommunications Agency during the 2000 3G auction and from the general wording of the 3G Information Memorandum that Ofcom's approach to spectrum management	As set out in Sections 3 and 4, we do not agree that any legitimate expectations arise from the award of 3G licences in 2000 which are in conflict with the decisions set out in this Statement and we consider that the award is likely to promote competition and to overall bring benefits to consumers.

	would not change without a significant change in circumstances. Additionally, T-Mobile suggested that this made it reasonable for the market to assume that the release of any additional spectrum would not substantially harm the interests of licensees of the original 3G auction. *From responses to the Discussion Document:* T-Mobile reiterated its point on legitimate expectations from its response to the December 20006 Consultation. A confidential response also raised concerns about potential legitimate expectations.	
MoUs with Ireland and France	*From responses to the December 2006 Consultation:* BT, O2, Orange, T-Mobile and Vodafone were of the opinion that interference from use of the band in France and Ireland must be fully understood before the award and that a Memorandum of Understanding (MoU) should be established with France and Ireland. *From responses to the Discussion Document:* BT expressed concern over the progress on finalising cross-border MoUs and urged Ofcom to complete this as soon as possible. O2 reiterated its request that MoUs be established prior to any award. The UMTS Forum believed that cross border issues could lead to areas where it would be impossible to deploy a service due to interference. *From responses to the Auction Rules Consultation:* One respondent called for progress to make firm MoUs with France and Ireland prior to the award, and criticised the lack of progress. Another respondent asked for the MoUs to be concluded ahead of the award.	We have concluded Memoranda of Understanding with France and Ireland. These are included in the Information Memorandum published alongside this Statement and discussed in Section 5 of this Statement.

Principle and timing of award

Issue raised	Comments	Ofcom's response
Awarding the spectrum as soon as practicable	*From responses to the December 2006 Consultation:* Arqiva, BAA, BT, the GSA (Global mobile Suppliers Association), Intel, Motorola, Siemens, Sprint Nextel and the WiMAX Forum supported the view that any award should take place as soon as practicable. The UMTS Forum agreed that an award should take place as soon as practicable if the UK adhered to the CEPT band plan and Ofcom kept EU developments under review. JFMG argued that an award should only take place once interference to PMSE users was fully understood. In addition to arguments raised for a delay due to linkages to other spectrum and European and other international regulatory discussions, H3G, Orange, T-Mobile and a confidential response suggested that any award should either be delayed until after the 10-40 GHz band and L-band awards to allow for refinement of the auction process or be delayed until all potential bidders could accurately assess their demand. UK Broadband argued that a decision on its request for a licence variation in the 3.5 GHz band be made prior to the publication of an Information Memorandum. *From responses to the Discussion Document:* BT, Motorola and the WiMAX Forum reiterated their position that the award should be made as soon as practicable. Nortel and Urban WiMAX stated that the award should be made as soon as reasonably practical. O2 believed that, in light of the 2G liberalisation consultation, Ofcom should not proceed with the 2.6 GHz award. T-Mobile and two confidential responses stated their position that the award should be delayed. A confidential response suggested the award of just the portion of the band which is for TDD use under the CEPT band plan, with the award of the remainder delayed until decisions on 2G/3G liberalisation are made. The	We have decided to award the 2.6 GHz band in its entirety as soon as is practicable. Please see Section 3 for more details of our approach to the timing of the award. In making that decision, we have taken account of the 10-40 GHz award and of European developments. This Statement includes our final analysis and the technical conditions for the award, including in respect of PMSE. We published our decision on UK Broadband's licence variation request at the end of 2007. Annex 3 of this Statement also includes an update on relevant market information regarding demand for use of the 2.6 GHz band internationally, development of suitable equipment for use in the band and demand for mobile broadband services. This information, combined with the expressions of interest we have received for use of the band in the UK, provides a clear indication of the significance of demand for use of the band.

	same response considered that Annex 12 (Evidence of demand for use of the 2.6 GHz band) of the Discussion Document did not provide sufficient evidence to support the award of the band as soon as practicable.	
Timing of 2290 MHz award relative to 2.6 GHz and 2010 MHz award	*From responses to the December 2006 Consultation:* BT, the GSA, O2 and Voadfone supported awarding the 2290 MHz band in advance of the 2.6 GHz and 2010 MHz award. David Hall Systems and Intellect argued for awarding this band following the award of 2.6 GHz and 2010 MHz. *From responses to the Discussion Document:* BAA suggested delaying the award of the 2290 MHz band until after the 2.6 GHz and 2010 MHz bands.	In the Discussion Document, we decided to separate the award of the 2290 MHz band from the 2.6 GHz award process and to consider it again at a later date, given the limited interest in the 2290 MHz band and the varying views on whether any award should be held before the 2.6 GHz auction and the likely benefits from these awards.
Timing for remaining PMSE users to vacate the spectrum	*From responses to the December 2006 consultation:* The BBC suggested that the 2.6 GHz band should continue to be made available for PMSE use on a rolling basis until the spectrum is assigned, and the requirements of PMSE users to vacate the spectrum should be linked to the geographical roll-out of services. *From responses to the Discussion Document:* The BBC. ITN, JFMG Ltd. and SPMF raised concerns regarding the future amount of spectrum which could be available for use by PMSE users following any award of the 2.6 GHz band and other spectrum bands proposed by Ofcom. Arqiva requested a guarantee that existing PMSE users would be given 3 months' notice only when new licences are awarded. The BBC reiterated its view that PMSE should be permitted to use the spectrum until the new licence holders are ready to switch on their services. SPMF requested clarity on when PMSE users would be expected to vacate the spectrum, and asked that PMSE be allowed to continue using the spectrum until new services switch on.	We are reviewing the wider framework for the use of spectrum by PMSE. Currently, PMSE users are on a three month notice period regarding access to the 2.6 GHz band. Alongside the publication of this Statement we have sent notices to PMSE users, as set out in Sections 3 and 9.

Non-technical licence conditions

Issue raised	Comments	Ofcom's response
Proposed licence conditions compared to existing licence conditions	*From responses to the Discussion Document:* O2, T-Mobile and a confidential response stated that the proposed non-technical licence conditions (in particular, technology neutrality, roll-out obligations and tradability) would be discriminatory towards existing licence holders, with T-Mobile reiterating that it felt that existing licence holders would be placed at a significant disadvantage.	Please see Section 4 (Non-technical licence conditions) of this Statement for our consideration of this issue and our view that the decisions are not unduly discriminatory and will promote competition.
Application of technology and service neutrality	*From responses to the December 2006 Consultation:* BAA, BT, David Hall Systems, Inquam, Intellect, Motorola, the Nomad Forum, Samsung, Sprint Nextel, UK Broadband, Wireless Communications Association International (WCAI), the WiMAX Forum and two confidential responses all expressed support for technology and service neutrality. Vodafone expressed support for technology and service neutrality, but was also of the opinion that existing 2G and 3G licences should be amended to be in-line with the new licences. The BBC expressed concerns about the potential for spectrum wastage (through the need for guard bands) if technology neutrality were applied. Bouygues, the GSA, Qualcomm and the UMTS Forum supported restricting the use of the spectrum to IMT-2000 technologies. H3G argued that the December 2006 Consultation did not provide evidence or analysis to show that the use of technology neutrality would provide substantial net benefits to the UK economy and its citizens and consumers. Nokia argued that an entirely technology neutral approach would endanger interoperability. Orange commented that it believed that the specification of 5 MHz blocks and 120 MHz duplex spacing for FDD meant that Ofcom's proposals were not technology neutral and suggested that licences in the 2.6 GHz band should be assigned to IMT technologies. Ericsson broadly agreed with the proposal of technology neutrality,	We have derived technology neutral conditions for the use of the 2.6 GHz and 2010 MHz bands which are designed to manage the risk of interference between users, provide flexibility to licensees and enable the benefits of harmonised use and interoperability (including incoming services). This is discussed in more detail in Sections 4 and 5.

	subject to concerns that the pursuit of flexibility could potentially reduce consumer benefits from wide area roaming systems of the GSM and UMTS/IMT-2000 types. Siemens commented that the introduction of numerous technologies and lack of interoperability should be avoided. T-Mobile suggested that the proposed licences should include the same conditions as the existing 3G licences and that technology neutrality should satisfy certain criteria which imply use of the CEPT band plan. *From responses to the Auction Rules Consultation:* One respondent did not agree with Ofcom's analysis of why the proposed approach regarding technology neutrality is not discriminatory.	
Discrimination and the effect of different licence conditions	*From responses to the Discussion Document:* T-Mobile reiterated that existing licence holders would be placed at a significant disadvantage compared to 2.6 GHz licensees. O2 stated that it considered the existence of different licence conditions for current 3G licences discriminatory, and did not believe that Ofcom had addressed the issue of external pairing where one half of the pair has more restrictive licence conditions than the other. *From responses to the Auction Rules Consultation:* One respondent did not agree with Ofcom's analysis of why the proposed approach regarding technology neutrality is not discriminatory. T-Mobile reiterated its view that the proposals are discriminatory against current licence holders.	See Section 4 for a discussion of the claims regarding discrimination against existing licensees. We are not taking any particular steps to facilitate or promote the external pairing of unpaired spectrum with other spectrum bands in this award. However, if, post-award, 2.6 GHz licensees wish to explore that possibility, they would do so within the terms of the licences. Holders of 3G licences could, if they deemed it necessary, apply for licence variations regarding external pairing.
Application of tradability	*From responses to the December 2006 consultation:* Arqiva, BAA plc, BT, David Hall Systems, Inquam, Intellect, the Nomad Forum, Sprint Nextel, WCAI and two confidential responses supported tradability for the licences. Vodafone expressed support for tradability, but believed that existing 2G and 3G licences should be amended to be in line with the new licences. Ericsson broadly agreed with the	We have decided to make licences for the 2.6 GHz and 2010 MHz bands tradable and consider that this is consistent with our statutory duties, in particular regarding optimal use of the spectrum. Please see Section 4 (Non-technical licence conditions) of this Statement for more information. We have made proposals regarding tradability for existing 3G licences separately in September 2007 in our consultation on the liberalisation of 2G and 3G spectrum.

	application of tradability, subject to concerns that the pursuit of flexibility could potentially reduce consumer benefits from wide area roaming systems of the GSM and UMTS/IMT-2000 types. The GSA and Siemens supported trading subject to maintaining technical obligations and rights and highlighted possible loss of economies of scale should the spectrum become fragmented under trading. Similarly, the UMTS Forum supported tradability as long as the type of usage, the technical obligations and rights of spectrum users would remain unchanged in relation to European harmonised bands. Orange believed that applying tradability would be in line with an overall policy of spectrum trading, but noted that secondary trading may not be able to correct all issues arising from the initial award. Samsung believed that tradability could be desirable in terms of efficient spectrum re-deployment but was concerned by the risk of spectrum hoarding. T-Mobile commented that the licence conditions in the new licences and those in the existing 3G licences should be aligned. *From responses to the Discussion Document:* O2 requested clarity on the tradability of 3G licences and roll-out obligations. The Nomad Forum was concerned that the 90 MHz spectrum cap may allow some TDD bidders to 'corner' the market, which could have an impact on secondary trading.	
Tenure of the licences	*From responses to the December 2006 consultation:* Arqiva, BAA plc, BT, David Hall Systems, Inquam, Intellect, the Nomad Forum, Sprint Nextel and a confidential response supported Ofcom's proposals for licence tenure. The confidential response also suggested that licence holders should be subject to a review every 5 years during which they would have to demonstrate utilisation of spectrum. Vodafone expressed support for the tenure conditions set out by Ofcom, but thought that existing 2G and 3G	We have decided to award licences with an initial period of 20 years as part of an indefinite term. Please see section 4 (Non-technical licence conditions) of this Statement for more information.

	licences should be amended to be in line with the new licences. A confidential response supported Ofcom's proposals and asked that Ofcom considered equality in the application of licence conditions relating to the five year notice for revocation on spectrum management grounds. Ericsson broadly agreed with the tenure conditions proposed by Ofcom, subject to concerns that the pursuit of flexibility could potentially reduce consumer benefits from wide area roaming systems of the GSM and UMTS/IMT-2000 types. H3G expressed concern about the potential for distorting competition depending on whether 2G and 3G licences were liberalised. T-Mobile commented that the licence conditions in the new licences and those in the existing 3G licences should be aligned.	
Absence of roll-out conditions	*From responses to December 2006 Consultation:* BAA plc, BT, David Hall Systems, the GSA, Inquam, Intellect, Siemens and two confidential responses supported the absence of roll-out conditions. Arqiva considered that any bidders who agreed to roll-out obligations in advance could be offered bidder credits in return. Vodafone expressed support for the absence of roll-out conditions, but believed that existing 2G and 3G licences should be amended to be in-line with the new licences. Ericsson broadly agreed with the absence of roll-out conditions, subject to concerns about the reduced consumer benefits from certain wide area roaming systems. . H3G expressed concern about the potential for the distortion of competition if licences did not include roll-out obligations and suggested that Ofcom should consider applying such conditions (or similar corrective measures) on an *ex ante* basis. Motorola agreed with Ofcom's proposals as long as Ofcom tried to ensure the spectrum won was used. The Nomad Forum agreed with the proposed absence of roll-out conditions but noted that there may not be a suitable level of coverage in rural areas	We have decided not to include any roll-out obligations in the licences for use of the 2.6 GHz and 2010 MHz bands. Please see Section 4 (Non-technical licence conditions) of this Statement for more information.

	as a result. Sprint Nextel agreed with the absence of roll-out conditions and suggested that licence holders should be required to have 'substantial service' or 'safe harbour' conditions. Orange and Samsung suggested that roll-out conditions should be applied to licences in the 2.6 GHz band. T-Mobile commented that the licence conditions in the new licences and those in the existing 3G licences should be aligned. *From responses to Discussion Document:* A confidential response stated that the lack of a coverage obligation could create unfair and discriminatory conditions. *From responses to the Auction Rules Consultation:* One respondent did not agree with the analysis of why Ofcom's approach is not discriminatory regarding roll-out obligations.	

Spectrum packaging (including potential for variation from the CEPT band plan)

Issue raised	Comments	Ofcom's response
Allowing flexibility in the split between TDD and FDD	*From responses to the December 2006 consultation:* Arqiva, BAA plc, David Hall Systems, Intel, Samsung and the WiMAX Forum agreed with Ofcom's proposal to allow flexibility in the split between FDD and TDD. Bouygues Telecom, Ericsson, the GSA, H3G, Nokia, O2, Orange, Qualcomm, Siemens, T-Mobile and the UMTS Forum argued that the CEPT band plan should be adhered to in the UK, citing concerns over handset/equipment development compared to the rest of Europe and the impact on international roaming. Bouygues Telecom and the GSA raised concerns over cross-border coordination with France and Ireland. The GSA, H3G, T-Mobile and a confidential response raised concerns over the level of Interference between TDD and FDD mobiles and base stations should the UK vary from the	We have decided to allow the market to determine, through the auction process, how much spectrum in the 2.6 GHz band will be used as paired and unpaired (individual) lots, while providing suitable conditions for the realisation of harmonisation benefits. Please see Section 4 for more information regarding the issue of technology neutrality and Section 5 for more information regarding the issue of interference between users of the 2.6 GHz band. As discussed in Sections 4 and 7, we do not consider that our decisions regarding licence conditions, including in respect of technology neutrality and flexibility in the award, are unduly discriminatory against any party.

	CEPT band plan. Motorola supported as much international harmonisation as possible to lever economies of scale in equipment production. The WCAI highlighted that experience in the US showed that technologies described by some as incompatible can coexist without undue interference. H3G considered that flexibility only in the favour of TDD discriminates against FDD. *From responses to the Discussion Document:* BT supported flexibility between FDD and TDD. Motorola reiterated its view that flexibility between TDD and FDD was suitable given the current market demand. Ericsson, Nokia Siemens, Qualcomm, T-Mobile and the UMTS Forum reiterated their view that a departure from the CEPT band plan would potentially disadvantage the UK. T-Mobile suggested that WiMAX could be used in half duplex FDD mode rather than allowing the split between TDD and FDD to vary.	
Packaging of the 2.6 GHz band	*From responses to the December 2006 Consultation:* Arqiva, BAA plc, BT, David Hall Systems, Ericsson, the GSA, Orange, Qualcomm, Samsung, Siemens, T-Mobile, Vodafone, the WiMAX Forum and a confidential response agreed with the proposed packaging of the 2.6 GHz band (lots of 2x5 MHz for paired use and 5 MHz for unpaired use, with the aggregation of lots). Motorola agreed with the proposals and noted that WiMAX and LTE may need channels of more than 10 MHz. The UMTS Forum agreed with the proposals and noted that it saw a need for 2x20 MHz per operator for LTE. Sprint Nextel argued that the spectrum should be packaged in 2x10 MHz lots for paired use and 10 MHz lots for unpaired. H3G, O2, T-Mobile and the UMTS Forum argued that provisions should be included to allow the pairing of 2600-2620 MHz with existing 1900-1920 MHz holdings. O2 further suggested that there should	We have decided to use blocks of 5 MHz for the award, with two types of lots at 2.6 GHz - paired lots comprising two blocks of 5 MHz and unpaired (individual) lots comprising one block 5 MHz, consistent with relevant European discussions. We have also decided to allow the aggregation of lots through combinatorial bidding, which allows participants to make bids for the packages they actually would like to receive. Please see Section 7 of this Statement on auction design for more information. We have not included any provisions designed to specifically facilitate external pairing. Section 5 includes our analysis of the relative usability of different blocks in the 2.6 GHz band and our conclusion that any differences (as a result of technical licence conditions and interference conditions) would only likely be very limited.

	be two types of paired and TDD lots ('lower' and 'upper') as a result of the risk of interference. Orange and T-Mobile argued that contiguous assignments were essential, with Orange also of the view that FDD blocks immediately adjacent to TDD would be of lower value than elsewhere.	
Packaging of the 2010 MHz band	*From responses to the December 2006 Consultation:* Arqiva, BAA plc, BT, David Hall Systems, the GSA, Inquam, Intel, Intellect, Motorola, Orange, Qualcomm, Samsung, Siemens, the UMTS Forum, Vodafone and a confidential response agreed with Ofcom's proposals to package the 2010 MHz band as a single lot of 15 MHz. The BBC argued that the 2010 MHz band should be allocated to JFMG for use by PMSE as interference conditions made it unsuitable for any other use. Ericsson commented that pairing of the 2010 MHz band with 2.6 GHz should be an option. Wrege Associates commented that the 2.6 GHz band and the 2010 MHz band should be awarded in the same process if there were substitutability or complementarities. BAA plc and the Nomad Forum considered that the 2.6 GHz and 2010 MHz bands were sufficiently different that they should be awarded separately. Orange argued that the 2.6 GHz and 2010 MHz bands should not be awarded in a single auction because of the uncertainties in the usability of the spectrum and suitability of the auction process.	We have decided to package the 2010 MHz band as a single lot and award it as part of the same process as for the 2.6 GHz band. Please see Section 7 of this Statement for more information.
Packaging of the 2290 MHz band	*From responses to the December 2006 Consultation:* Several respondents agreed with Ofcom's proposals to package the 2290 MHz band as a single lot of 10 MHz. The BBC argued that the 2290 MHz band should be allocated to JFMG for use by PMSE as interference conditions made it unsuitable for any other use. The GSA considered that the 2290 MHz band should be treated in a separate process to the other bands. H3G argued that the 2290 MHz band was not a substitute or complement to the 2.6 GHz or 2010 MHz bands.	In the Discussion Document, we decided to separate the award of the 2290 MHz band from the 2.6 GHz award process and to consider it again at a later date, given the limited interest in the 2290 MHz band. In the interim, we have made the band available for PMSE use on a temporary basis.

	From responses to the Discussion Document: The BBC stated that the 2290 MHz band should be set aside for PMSE use.	

Auction design

2.6 GHz and 2010 MHz award

Issue raised	Comments	Ofcom's response
Complexity of auction design/ further testing required	*From responses to the December 2006 Consultation:* Arqiva, David Hall Systems and two confidential responses considered that the auction design was complicated and may discourage bidders or risk an inefficient result. H3G argued that the proposed auction design required further testing and refinement prior to being implemented. *From responses to the Discussion Document:* Two respondents maintained that the auction design, in spite of modifications, was still complex. One respondent thought that further testing was required. *From responses to the Auction Rules Consultation:* One respondent stated that there was not sufficient testing of the auction design.	We have developed the auction design which in our view best meets our objectives, derived from our statutory duties, for this award. We believe that the auction design that we have chosen strikes the right balance between flexibility for the market to decide the optimal use of the spectrum and managing complexity for bidders. Section 7 (auction design) includes more detail on our choices for the award process, on the issue of testing and the review of the 10/40 GHz award process.
Generic lots vs. specific lots	*From responses to the December 2006 Consultation:* Some respondents, including Arqiva and BT, supported the use of generic lots. Others, including H3G, T-Mobile and Vodafone, considered that the use of specific lots would be preferable. Some of the arguments raised by respondents against generic lots included external interference (from PMSE and radars) and adjacent channel interference. (These points are covered in more detail in the following sub-section of this Annex on Technical issues and interference.) *From responses to the Discussion Document:* Many respondents, including Arqiva, BT, Inquam, Intel, Intellect, Motorola and the WiMAX Forum, generally	Following responses to the December 2006 Consultation, we have undertaken considerable technical work looking at external interference issues and in-band adjacencies which might have impacted on the choice of generic over specific lots. The results of this work were presented in Section 3 of the Discussion Document and our further work is set out in Section 5 of this Statement. We conclude that any differences between the usability and value of lots in a given category in the 2.6 GHz band are limited and therefore, that the use of generic lots for the 2.6 GHz band is appropriate.

	concurred with our further analysis of interference conditions relevant to the use of generic lots. Some respondents, including Intel, Samsung and the WiMAX Forum, noted that the responsibility for mitigation and interference management should be shared amongst all users and technologies. Several respondents, while welcoming the further information provided, continued to have concerns with the potential for interference and questioned some of the technical conclusions set out in the Discussion Document. (These concerns are covered in more detail in the following sub-section of this Annex on Technical issues and interference.)	
Split awards of unpaired spectrum	*From responses to the December 2006 Consultation:* One respondent argued that certain configurations of split awards may result in one or both blocks being unusable for TDD applications and that the auction design should be modified to account for this. *From responses to the Discussion Document:* One respondent requested that bidders for a split award to be allowed to specify the number of lots in each of the central and upper areas of the band. A confidential response suggested dropping the option of allowing split unpaired assignments until the Assignment Stage. *From responses to the Auction Rules Consultation:* One respondent argued that Ofcom should allow the specification of the location of each part of a split award and suggested an amendment to the rules allowing any bidder who so wishes to submit valid supplementary bids on all possible permutations of its specified split ratio.	As set out in more detail in Section 7 (auction design), we have decided to allow bidders to make bids for split awards if they wish (additional supplementary bids), but that those bidders will not be able to specify which part of the band each part of the split bid would fall in. Whether split bids are included in the winning combination of bids needs to be determined as part of the Principal Stage outcome. Section 5 includes an analysis of the interference conditions in the 2.6 GHz on the basis of the final technical conditions.
Switching between paired and unpaired spectrum	*From responses to the December 2006 Consultation:* H3G, T-Mobile and Vodafone argued that bidders should be able to switch between paired and unpaired spectrum. *From responses to the Discussion Document:* Arqiva and Inquam agreed that bidders should be able to switch demand between categories.	As set out in Section 7 and consistent with our proposals in the Auction Rules Consultation, we are allowing bidders to switch between categories of lots (through fungible eligibility across categories) and to express all their preferences in the supplementary bid round. On Inquam's point, we consider that an

	One respondent was concerned that bidders could behave strategically and frustrate price discovery in the primary bid rounds by bidding on paired lots when their true demand was for unpaired lots and then switch in the supplementary bids round. They suggested that this risk could be removed by constraining uncapped supplementary bids by giving them zero fungibility. *From responses to the Auction Rules Consultation:* Arqiva and one other respondent supported switching. Inquam believed that strategic behaviour could occur regarding the 2010 MHz band, with bidders parking demand there, and made a proposal for change, that eligibility rights for the two bands should not be exchangeable except in the case of no demand for the 2010 MHz band.	important deterrent against strategic behaviour (in relation to parking in the 2010 MHz band) is that all valid bids are used in the winner determination calculation. Any bidder who does not actually wish to win the 2010 MHz band and engages in such a strategy would run the risk of winning the lot and having to pay for it. While recognising that an element of risk remains, we believe that the substitution and aggregation risks associated with de-linking eligibility for the 2010 MHz band are greater than the risks of allowing switching. Therefore, we do not intend to remove the ability to switch between the 2010 MHz lot and 2.6 GHz lots.
External pairing	*From responses to the December 2006 Consultation:* O2, T-Mobile and a confidential response suggested that the auction should be modified to facilitate external pairing of the band with existing spectrum holdings. *From responses to the Discussion Document:* O2 did not believe that Ofcom had addressed the issue of external pairing where one half of the pair has more restrictive licence conditions than the other (including tenure). A confidential response stated that the proposed design did not realistically allow for pairing of spectrum in the band with existing spectrum holdings, and that it would like to see this option facilitated. Qualcomm suggested that we should let the market decide on the inclusion or exclusion of the option for external pairing. *From responses to the Auction Rules Consultation*: One respondent continued to argue for external pairing to be facilitated and thought that Ofcom had not conducted a proper analysis of this issue.	We conducted analysis of the potential to modify the auction design to facilitate external pairing of lots in the 2.6 GHz band with other spectrum bands and set this out in paragraphs 5.33 – 5.53 of the Discussion Document. Our conclusion was that facilitating such a change in the auction design would introduce a disproportionate amount of complexity compared to any potential benefit. As discussed further in Section 7, we remain of that view and we have therefore decided not to make any changes to the auction process in order to specifically facilitate external pairing.
Base price and winner	*From responses to the December 2006 Consultation:*	In Annex 11 of the Discussion Document, we described the process and conditions we would use for winner

determination	H3G and Vodafone considered that the auction design did not fully explain how prices are determined from bids. Wrege Associates considered that Ofcom should publish the specific algorithms for the BAFO and final assignment stages. *From responses to the Discussion Document:* One response requested proof of the existence and uniqueness of base prices at the end of the Principal Stage, and asked that Ofcom set out a deterministic procedure for the calculation of base prices. A second response questioned whether the description of additional prices during the Assignment Stage in the Discussion Document was such that they could be indeterminate. A third response requested clarification of the calculation of base prices in the Principal Stage, asking if the calculation of the "modified bids" in the algorithm presented in the Discussion Document was constrained so that they were above the reserve price (or above zero). *From responses to the Auction Rules Consultation:* Two respondents continued to argue that the process of price determination was very complex. One of the respondents requested that Ofcom make available the award software that will be used to determine winners and prices. The other respondent did not consider that sufficient detail had been provided to allow bidders to understand how prices will be determined in all circumstances, and requested further information.	determination and to determine the base price for winning bids. The points on the uniqueness of base prices at the end of the Principal Stage and whether additional prices in the Assignment Stage would be indeterminate are addressed in an explanatory note published in relation to the 10-40 GHz award[129]. The demonstration contained in Section 4 of that note equally applies to the calculation of base prices and additional prices under the proposed award of the 2.6 GHz and 2010 MHz bands. Further detail on the calculation of base prices is included in Section 7 of this Statement and in the Information Memorandum. We intend to make the award software available in advance of the auction. This will allow interested parties the opportunity to construct their own worked examples to understand how the rules will work in practice.
Eligibility	*From responses to the Discussion Document:* Vodafone identified problems regarding eligibility points and paired and unpaired spectrum. One respondent requested that Ofcom re-examine its justification for allocating only two eligibility points for the 2010 MHz band. They noted that in the December 2006 Consultation, Ofcom	In the Auction Rules Consultation, we acknowledged the issue raised by Vodafone and proposed to change the eligibility points associated with bids for unpaired spectrum to account for the lot(s) with restricted usage rights. Respondents to the Auction Rules Consultation either supported or made no comment on the proposed change and we have therefore decided to

129 http://www.ofcom.org.uk/radiocomms/spectrumawards/completedawards/1040award/key/licencefees/fees.pdf

	justified this decision based on the fact that the block only consisted of 12.5 MHz of spectrum but that the Discussion Document indicated that the band contained 15 MHz of spectrum. They thought that the relative value of this block compared with the 2.6Hz band should be defined by the results of the auction process and that Ofcom should therefore allocate three eligibility points to the band rather than two.	implement it. As discussed in Section 7, although it includes 15 MHz of spectrum, we do not consider that it would be appropriate to change the eligibility points associated with the 2010 MHz lot to 3. Also, with the auction design we adopted, the relative value of the 2010 MHz band and lots in the 2.6 GHz band will be determined through the award.
Release of information during the auction	*From responses to the December 2006 Consultation:* Some respondents thought that the auction should contain a greater degree of transparency and presented several suggestions on ways to increase it. *From responses to the Discussion Document:* One respondent suggested that details of all bids should be revealed on an anonymous basis at the end of each primary round. Another respondent thought that all Principal Stage bids should be published before the Assignment Stage commences so that winning bidders could understand why they have to pay the amount required or, in some cases, why they are being awarded paired rather than unpaired spectrum. Some respondents also argued that they needed this information in order to explain to their boards/budget holders precisely why their base price is as it is. One respondent suggested that full details of all assignment options should be published in the Assignment Stage because in their view the identity of neighbouring operators would affect the valuation of a particular frequency assignment and this knowledge would allow the Assignment Stage to run more efficiently. *From responses to the Auction Rules Consultation:* Arqiva, Inquam and T-Mobile supported the changes to the information policy. One other respondent wanted anonymised bids disclosed to bidders with consistent labelling from round to round. T-Mobile wanted an amendment to Regulation 35 to reflect Ofcom's proposals regarding transparency.	We have decided to release to bidders information on aggregate demand per category of lots during the primary bid rounds. We have also decided to publish information about the identity of bidders, about the identity of winners and the amounts of spectrum won at the end of the Principal Stage (and default if any), and about all bids made and the licences fees paid at the end of the process. This is discussed in more detail in Section 7. We may also publish information from time to time on the level of demand per category of lot. In the Assignment Stage, winners will know who the other winners are, but will not be able to bid depending on who their neighbours are (see contingent bidding below). The Draft Auction Regulations published alongside this Statement include clear provisions regarding the information that we will or may make available.
Contingent	*From responses to the Discussion*	In the Auction Rules Consultation, we noted that allowing such contingent bids

bidding	*Document:* One respondent suggested that bids for specific frequencies in the Assignment Stage could be contingent on the identity of neighbours. One respondent suggested that we introduce contingent bidding dependent on whether or not unpaired spectrum is present at the top of the 2.6 GHz band. *From responses to the Auction Rules Consultation:* One respondent disagreed with the proposal not to allow contingent bidding dependent on neighbours in the Assignment Stage, saying that the contingent nature of the valuation of different bands (including a dependency on neighbours) means that certain classes of bidders will be disadvantaged and subject to additional risk in the proposed auction and that this will make the derivation of appropriate bidding strategies exceedingly difficult.	would create opportunities for some bidders to very directly influence which spectrum their competitors would receive. We also noted that this would significantly increase the complexity of the auction. We therefore proposed not to make this change. In Sections 5 and 7 of this Statement, we set out our conclusion that technical analysis of adjacent channel interference (ACI) and mobile-to-mobile blocking indicates that the value of lots will not materially depend on the presence (or absence) of unpaired spectrum in the upper part of the 2.6 GHz band. Therefore, we do not think there is sufficient justification for introducing contingent bidding dependent on whether or not unpaired spectrum is present at the top of the 2.6 GHz band and have decided not to implement this change. We note that the response to the Auction Rules Consultation on this issue did not provide any new evidence to support their argument or that caused us to rethink the arguments set out in the Auction Rules Consultation and we have therefore decided not to make any change in this regard.
Deposits	*From responses to the Discussion Document:* Several stakeholders felt that a deposit of 100% of the highest bid made so far was too onerous given the potentially high value of the lots in this award. One respondent proposed that there should be a fixed rule for when deposits should be increased, based on the ratio of existing deposits to prices. Another respondent questioned whether interest would be paid on cash deposits held by Ofcom. One respondent also asked whether bank guarantees would be acceptable in lieu of cash deposits. *From responses to the Auction Rules Consultation:* BT and T-Mobile agreed with the lower level for the deposit. One respondent believed that the interest accrued on deposits may be substantial and requested a review on the decision on refunds of interest accrued. It also proposed that Ofcom uses an escrow account for the	As set out earlier in Section 7 of this Statement, we have decided not to refund interest on deposits for this award. We also do not think an escrow account is necessary as existing auction account arrangements provide a suitable arrangement for managing bidders' deposits. In some cases, the notice periods given for deposit payments may be less than two business days, but we consider that the length of time provided will give bidders sufficient time within which to prepare to pay any extra deposit amount required while allowing us to proceed with the auction at a reasonable pace.

	payment and receipt of deposits providing depositors with surety regarding their monies. T-Mobile requested that 2 business days notice be given of the deadlines for deposit payments.	
Defaults	*From responses to the Auction Rules Consultation:* Arqiva believed that Ofcom should not leave lots unsold in the case of default by a Principal Stage winner but should consider allowing valid bids from other bidders (who, prior to the default had not had a bid accepted) to fill the gap. One respondent was concerned about the potential for accidental default. It proposed that the auction bid software provides positive confirmation or warnings back to the bidders that their deposit has or has not been received and their current status regarding eligibility to continue bidding.	We note that allowing other valid bids to fill the "gap" left by a defaulting winning bidder results in certain undesirable consequences. It could potentially result in spectrum not being won by the bidder who valued it most and it is likely that the combination of bids made up of the winning bids at the time of default (minus the defaulted bidders bid) plus any bid(s) used to fill the gap would no longer be the winning combination of bids. We have therefore decided not to implement a change in that respect. On accidental default, we note that the process for payment of deposits runs independently of the award software and there is no functionality in the auction software which would allow us to automatically inform bidders of the receipt of monies. It is up to bidders to take the necessary steps to ensure that monies are received by Ofcom by the specified deadlines.
Payment schedule	*From responses to the Discussion Document:* Bluenowhere and Nokia Siemens suggested that we could allow phased payment for licences.	Phased payments create credit risk for us because of the risk of default by a bidder that has committed to a payment schedule. This also creates risks for the integrity and efficiency of the auction, as the spectrum could go to parties who do not have the highest value for it and are not best placed to put it into use. The auction process is also designed so as to encourage participation (for example through the absence of a participation fee, or the deposit requirements). Therefore, we have decided not to permit phased payment of licence fees.
Bidder credits	*From responses to the December 2006 Consultation:* Arqiva considered that Ofcom could introduce bidder credits for uses of the spectrum which would be likely to be a broad source of value to society or where the user base is sufficiently disparate that its ability to participate in an auction would be limited. They thought that digital wireless cameras may merit such treatment.	Use of bidder credits is one of the intervention options available to deal with market failure. There are some risks with this approach, e.g. reducing flexibility in spectrum use and encouraging those eligible to receive bidder credits to be less efficient in terms of choosing between spectrum and non-spectrum inputs needed to deliver a service. To use bidder credits (or any other intervention option), we would need to have clear evidence of market failure. We have not identified (and not received) any compelling evidence that a potential for such

		market failure exists with relation to the award of these frequency bands and we are therefore not using bidder credits for this award.
Number of rounds per day and timing of rounds	*From responses to the Discussion Document:* Arqiva commented that conducting more than one round per day in the later rounds of the auction may cause some difficulties for bidders with internal sign-off processes. T-Mobile felt that the notice period of 15 minutes before the start of rounds may be insufficient to allow bidders to properly prepare.	Ofcom can control the "speed" of the auction through both the number of rounds per day and the level of price increases between rounds. We retain discretion to manage that speed flexibly and we have experience with a similar auction design through the 10/40 GHz which concluded in February 2008. Prices in the later stages of the primary bid rounds are unlikely to be increasing so fast that it would be difficult for bidders to predict when their limits are likely to be breached. The Information Memorandum published alongside this Statement contains guidance regarding the way in which we are likely to conduct the process and we expect to make further guidance available ahead of the start of the Principal Stage.

2290 MHz award

Issue raised	**Comments**	**Ofcom's response**
General	*From responses to the December 2006 consultation:* Arqiva, BAA, BT, Ericsson, O2 and Vodafone generally agreed with the proposals.	In the Discussion Document, we decided to separate the award of the 2290 MHz band from the 2.6 GHz award process and to consider it again at a later date, given the limited interest in use of the 2290 MHz band.
Separate process for 2290 MHz band	*From responses to the December 2006 consultation:* Ericsson, GSA, H3G, Qualcomm, Siemens and UMTS agreed that this award should be a separate process from the other two bands.	
Timing of award	*From responses to the December 2006 consultation:* The Nomad Forum believed that the 2290 MHz band should be awarded after the other two bands.	
Preference for multi-round process	*From responses to the December 2006 consultation:* Wrege Associates thought it was unlikely that there would be insufficient demand for the band and suggested a multi-round process to facilitate price discovery.	
Allocation to PMSE	*From responses to the December 2006 consultation:* The BBC stated that the band should be	

	assigned to PMSE. David Hall Systems suggested that one approach would be to award the band to a spectrum manager for PMSE use. GSA suggested that the band may be of use to PMSE.	

Conditions relating to individual bidders

Issue raised	Comments	Ofcom's response
Use and size of spectrum cap	*From responses to the December 2006 Consultation:* A clear majority of respondents were in favour of having some kind of safeguard cap. Of the 23 responses which clearly stated agreement or disagreement with Ofcom's proposals on this issue, 17 clearly supported a cap and 6 were against. Of those who supported the idea of a spectrum cap, most felt that 90 MHz was a sensible level although some argued for a lower cap (but without providing analysis to demonstrate the nature of the potential competition concern that could justify a lower figure). Some of the specific comments we received are as follows: BAA plc felt that 90 MHz was too high and 30 MHz would be suitable for the first five years, then increasing to 60 MHz. Nomad also thought 30 MHz was appropriate. Orange argued that a cap of 60 MHz was appropriate, and that this should be removed post award. BT argued that a 90 MHz cap was pragmatic but that it should cease to apply post award. The GSA and Siemens argued that any cap should be smaller than 90 MHz and suggested a value of around 2x20 MHz for paired and 30/35 MHz for unpaired. H3G requested clarity on how the cap would relate to other spectrum and to the secondary market. Inquam argued that the cap should apply to the total spectrum holdings of participants. A confidential response agreed with the need for a cap and argued that some form of governance should be introduced to ensure usage post award. *From responses to the Discussion*	In the Discussion Document, we set out our view that the main justification for employing a spectrum cap is as a safeguard against the risk that one party could acquire a large majority of the spectrum in the award and limit the opportunities for efficient spectrum use and for promoting competition in downstream markets. We noted reasons why the cap should be between 70-115 MHz and concluded that unless any stakeholders provided conclusive arguments in favour of another number, we were minded to keep the size of the safeguard cap at 90 MHz. We also noted that any restriction on trading in the secondary market could be circumvented by one firm acquiring another, and so extending the spectrum cap to the secondary market could be of little value. We proposed not to apply the safeguard cap to the secondary market. In the Auction Rules Consultation, we covered the point raised by a confidential respondent suggesting that the cap be amended to take into account restricted blocks when bidding for unpaired spectrum. We proposed to lower the spectrum cap to the equivalent of 80 MHz of standard (normal base station powers) spectrum in the 2.6 GHz band (that is, up to 90 MHz in the case of a split, unpaired assignment that contains two restricted blocks). We also noted that allowing one bidder to win 120 MHz of spectrum in order to run two separate networks was not a desirable outcome and asked for stakeholders' views on this. In Section 8 of this Statement, we set out our conclusions on the spectrum cap.

	Document: In general, responses to the Discussion Document were supportive of the inclusion of a spectrum cap, the value proposed in the Discussion Document and the proposal not to include an additional condition to address the risk of inefficient hoarding. Some respondents made specific points as follows: Bluenowhere suggested a lower spectrum cap for some existing spectrum holders. The Nomad Forum was concerned that a 90 MHz cap may allow a small number of TDD bidders to corner the market. One respondent requested that bidders be allowed to obtain enough spectrum to run two separate networks, each of 60 MHz, giving a total of 120 MHz. A confidential response suggested that the cap be amended to take into account restricted blocks when bidding for unpaired spectrum so that the cap would allow bidders for both paired and unpaired to bid for the same amount of fully useable spectrum. Another respondent thought that the proposed spectrum cap was inconsistent with our general approach to the auction and that a cap of 25% (45 MHz) would be consistent with an analysis of significant market power. *From responses to the Auction Rules Consultation:* Four respondents provided comments on the spectrum cap issue in their responses to the Auction Rules Consultation. Two accepted our proposed amendment to the safeguard cap of 80 MHz excluding restricted use channels (though one reiterated its reservations to the principle of using a safeguard cap at all). Two repeated the comments they had made in previous responses; while continuing to agree with the principle of the safeguard cap, they suggested different limits (90 MHz and 60 MHz).	On setting a lower cap for existing spectrum holders, we note that setting this would carry a risk of regulatory failure and we are not imposing different licence conditions for different parties. On the concern that a small number of TDD bidders could "corner" the market, we have not identified any risk of market failure in the downstream retail markets which would justify imposing a minimum number of licensees in addition to the safeguard cap that we are implementing. On significant market power issues, there is no evidence to suggest that, particularly given the spectrum cap that we are applying, a party could hold significant market power as a result of holding a licence for the available spectrum (and it is not clear in which market a licensee could hold such significant market power). However, we have powers for regulatory intervention at the time if such significant market power became apparent post-award. None of the responses to the Auction Rules Consultation provided any new evidence which has caused to change our view that 80 MHz of standard spectrum is a suitable limit for the cap. Therefore, we have decided that the auction will adopt a spectrum cap that is equivalent to 80 MHz of standard spectrum in the 2.6 GHz band and that this cap will only apply during the award process for the licences and will not extend to the secondary market.
Restrictions on particular bidders	*From responses to the December 2006 Consultation:* H3G and T-Mobile put forward their view that BT's participation in the auction should be restricted. H3G thought that any new mobile venture from BT should be subject to accounting separation. They claimed that the 1999	We have decided not to include any restrictions on specific parties or group of parties to participate in the award. Please see Section 8 for more detail on this issue.

	Information Memorandum for the 3G auction implied that, had BT been awarded a 3G licence, it would have been required to undergo accounting separation between its 3G business and the rest of its business, and thought there was no evidence to support a change in circumstances which would mean that accounting separation was no longer warranted. *From responses to the Discussion Document:* Two respondents thought that BT's participation in the award should be restricted. One of the respondents disagreed with our analysis in the Discussion Document and said that the important issue was whether there had been any substantial changes since 1999 in BT's position in the markets it could potentially leverage from, i.e. fixed network and retail services. One of the respondents also suggested that existing spectrum holders with unused or partially used spectrum should be restricted in some way. *From responses to the Auction Rules Consultation:* One respondent continued to argue that BT should be subject to specific restrictions in the proposed award.	
Bidder association and opt out mechanism	*From responses to the Discussion Document*: A respondent to the Discussion Document requested further clarity on how we would deal with a situation in which an MNO was asked to enter into a national roaming agreement with a potential bidder while also intending to bid on its own. Other respondents raised the issue of the difficulty in providing funding to a number of potential bidders under Ofcom's typical association rules. In particular, those respondents considered that the rules could have a negative impact on competition by limiting the ability of potential bidders to raise funding. Respondents considered that Ofcom should allow investors to hold an interest in more than one bidder provided that they do not receive confidential information, and are not involved in any decisions concerning the award, in respect of all but one bidder. *From responses to the Auction Rules Consultation:*	In the Auction Rules Consultation, we set out view that, in principle, it is possible for two parties to hold discussions on possible roaming agreements that could be struck post-award without breaching the activity rules set out in the Draft Auction Regulations, but that we need to retain the scope to take appropriate action depending on the exact nature of the information exchanged. On the impact of the rules on the ability to raise funding, we proposed to revise the auction regulations to allow a person holding a material interest in several applicants or bidders to "opt out" of holding an interest in several bidders but under certain conditions designed to safeguard the integrity of auction process, based on arrangements to be excluded from all but one bidder group subject to Ofcom's approval. Our conclusions on bidder association are set out in Section 8 of this Statement. We agree that the opt out process

	One respondent wanted the rules to be carefully drafted to avoid cases such as venture capitalists opting out of several groups or MNOs bidding in their own right and in a 50/50 joint venture. Another respondent was concerned about the risk that the opting out associate could hold information that is not confidential but is private information which could influence bidding. T-Mobile wanted more guidance on national roaming agreements. Arqiva stated that it wanted to explore ways to be able to provide advice to several bidders and potentially bid in its own right.	needs to be designed carefully and have been mindful of the need to prevent opportunities for applicants to put the efficiency and the integrity of the process at risk. However, we do not consider that allowing an associate to opt out from an applicant group would necessarily enable that associate to hold confidential information about the applicant group it has opted out of while participating in another bidder group. We have specified the detailed undertakings required from the opt out associate and the corresponding applicant at Schedules 4 and 5 of the Draft Auction Regulations. In respect of roaming agreements, we remain of the view that it is possible for interested parties to engage on those issues and still qualify as separate applicants in the award process, but that in doing so, they should take specific provisions to avoid contravening the rules that relate to the exchange of confidential information (e.g. Chinese walls) and receive advice as appropriate. Concerning the provision of advice to several applicants or bidders by one organisations, our view is that it is possible, within the framework of the draft rules for one party to do so but that they would likely have to take specific measures to ensure that no confidential information would flow from the persons advising applicants or bidders to others in the organisation (e.g. secondments and Chinese walls). We are therefore not changing the rules and regulations in relation to this issue.

Technical issues & interference

Issue raised	Comments	Ofcom's response
Mitigation techniques for TDD/FDD adjacency	*From responses to the December 2006 Consultation:* BAA questioned the practicality of the mitigation techniques described by Ofcom. O2 requested clarification of whether mitigation will be mandated.	Section 5 sets out our detailed analysis of the conditions of interference between users of the 2.6 GHz band, users of the 2.6 GHz band and users of adjacent bands, a user of the 2010 MHz band and users of adjacent bands. Section 6 provides a summary of our decisions for the technical conditions for use of the two available bands.
Proposed restricted blocks at TDD/FDD	*From responses to the December 2006 Consultation:* BT suggested that in-band guard block	

adjacencies	restrictions could be relaxed, but that a degree of coordination would be necessary between operators. The WiMAX Forum felt that the 5 MHz restricted block was a valid solution. David Hall Systems thought a restricted block and modified second block were required. Ericsson, Motorola, T-Mobile, Siemens and a confidential response believed that the suggested 5 MHz restricted band between TDD and FDD could be insufficient. H3G, Orange, Qualcomm and the UMTS Forum stated their views that restricted blocks at the TDD/FDD adjacencies should be unused guard blocks, with Qualcomm and the UMTS Forum further stating that the a second 5 MHz block should also be unused. T-Mobile requested clarity on whether the proposed restrictions would change if a channel bandwidth of more than 5 MHz were used. Intel suggested that operators may be best placed to determine restrictions at boundaries and should be permitted to agree on new requirements. Vodafone agreed on the restricted block at the adjacency but questioned the need for restrictions on the second adjacent channel. It also thought it necessary to have a process for neighbours to obtain licence variations if they coordinate or use better equipment. *From responses to the Discussion Document:* Nortel suggested that the requirement for restricted blocks at TDD/FDD adjacencies could be lifted if the same operator owned spectrum on both sides of the boundary and could coordinate internally. *From responses to the Auction Rules Consultation:* Motorola suggested that limits should be applied only where there is co-located FDD/TDD or un-synchronised TDD and interference mitigation techniques cannot b used. It also encouraged the practice of synchronising TDD systems wherever possible.
Potential Interference at TDD/FDD	*From responses to the December 2006 Consultation:* The BBC believed that interference to

adjacencies (including mobile-to-mobile blocking)	WLAN devices was underestimated. GSA expressed concerns about interference between mobiles and costly base stations. National Grid Wireless and Pipex Wireless requested more analysis of interference. Nokia questioned the assumptions made in the analysis of interference. It also expressed its concerns over the consequences of interference. Siemens expressed concerns about mobile to mobile interference and suggested that the 5 MHz block may not be usable unless the conditions are precisely identified. *From responses to the Discussion Document:* Arqiva, Inquam, Intel, Motorola, the Nomad Forum, Samsung and Urban WiMAX were satisfied with the proposals regarding mobile-to-mobile blocking. BT, Ericsson, Nokia, O2, Qualcomm, T-Mobile, the UMTS Forum and a confidential response had general concerns about the proposals and calculations, and suggested that Ofcom revisit its calculations. Intel and Intellect recommended that potential bidders would need to undertake their own review. Intellect and Motorola did not see interference as an issue to cause delay. The UMTS Forum requested that the analysis be repeated using a different separation. O2 questioned some of the conclusions regarding the scale of the potential blocking and the welfare benefits and losses of tuneable filters. Nokia Siemens commented that the value of services could be reduced as a result of interference. The UMTS Forum suggested that studies be undertaken at CEPT level. BT felt that some of the assumptions made regarding mobile blocking could be pessimistic. Nortel believed that commercial negotiation was likely to be the most efficient approach to possible blocking. Urban WiMAX felt that there was enough information and disputes should be solved through negotiation. The WiMAX Forum considered that

	there would be less blocking potential than suggested by Ofcom.
Interference to/from other uses (PMSE, satellite etc)	*From responses to the December 2006 Consultation:* Qualcomm agreed with Ofcom's analysis of adjacent band interference. Arqiva had some general concerns about interference but did not provide specific details. BAA believed that some of the techniques described by Ofcom to mitigate interference to or from other uses may not be practical. The BBC questioned the calculations made regarding interference and was concerned about the cost and sufficiency of mitigation. H3G stated that specific mitigation was necessary. JFMG believed interference effects were underestimated and questioned the parameters in the modelling. It also expressed its view that it was difficult to fit filters into temporary site equipment. A confidential response called for more analysis of interference. O2 requested clarification regarding the prevailing right of the existing licensee/user over the incoming adjacent user, and also asked for further work to be carried out on the question of interference to and from PMSE. T-Mobile requested clarification on interference from adjacent PMSE and whether filters would be required. Vodafone stated their view that it was necessary to consider the impact of space services. *From responses to the Discussion Document:* The BBC and ITN had concerns about interference from 3G services. JFMG was also concerned about interference and offered some solutions to mitigate. O2 was concerned that mitigation was put on incumbent PMSE users when it should be borne by the incoming licensees. SPMF believed that there had been an underestimation of interference on adjacent PMSE spectrum, and that the suggested mitigation techniques were either not viable or currently in use. Globalstar requested that the portion of

	the 2.6 GHz band nearest to the 2500 MHz boundary be limited to use by mobile terminals (uplink) and that terminals used in rural areas be further away from 2500 MHz to avoid interference with Globalstar terminals.
Interference to primary passive services >2690 MHz	*From responses to December 2006 Consultation:* Arqiva had general concerns about interference but did not provide specific details. BAA had concerns about the practicality of the mitigation techniques suggested by Ofcom. The BBC felt that the interference to air traffic control was understated. A confidential response felt that more analysis of the potential for interference was needed. O2 requested clarification on who would be responsible for mitigation if radio astronomy services or earth exploration satellite services (which have a primary allocation in the 2690-2700 MHz band) were to make greater use of the band in the future.
MoD & radar use	*From responses to the December 2006 Consultation:* Arqiva had general concerns about interference but did not provide specific details. BAA had concerns about the practicality of the mitigation techniques suggested by Ofcom. BT, H3G and O2 requested further information on use of the band by the MoD. GSA felt there was uncertainty over the level of interference. Orange and a confidential response requested further analysis of potential interference. T-Mobile felt that further clarity would be needed on the impact of MoD and air traffic control radars. *From responses to the Discussion Document:* NATS requested to know what safeguards would be put in place to mitigate the impact of mobile devices on radar. O2 asked for a reassessment of the potential for interference regarding radars.
Extension of out of block masks	*From responses to the Discussion*

to +/-20 MHz	*Document:* Arqiva, Nokia Siemens, Qualcomm, T-Mobile and a confidential response agreed with the proposal. Motorola thought that the proposal was not controversial. BT and Samsung questioned the benefit from the proposal. Intel, Nortel and the WiMAX Forum did not support the proposal. Ericsson disagreed with use of spectrum masks and, along with the UMTS Forum, urged Ofcom to wait for the results of ECC studies on frequency constraints in 2.6 GHz. Urban WiMAX raised some concerns with the proposals as they may place an additional burden on TDD bidders.
Further restriction of use of restricted blocks between FDD uplink and TDD	*From responses to the Discussion Document:* Arqiva agreed with the proposals set out in the December 2006 Consultation to further restrict the use at the adjacency between FDD uplink and TDD. Ericsson also agreed and stated that they would like guard bands between FDD (both uplink and downlink) and TDD. T-Mobile and O2 supported the reduction of in-band power of base stations to 18dBm/MHz. A confidential response supported the change and suggested further amendments. BT believed that reducing the restricted channel base station to 18dBm/MHz at the boundaries would seriously limit the usefulness of this spectrum. Inquam did not support further restrictions and, furthermore, suggested removing restrictions for indoor use. Intel and Nortel also did not support the restrictions. Intellect considered the constraint should only be as much as is necessary to avoid significant interference problems. Motorola accepted that additional restrictions on the guard band may be needed. Qualcomm questioned whether the 5 MHz restricted blocks would be usable in practice. Similarly, the UMTS Forum felt that guard bands would be required between TDD and FDD. Samsung suggested indoor usage

	restrictions, but as guidance/advice rather than a specific condition. Urban WiMAX raised some concerns with the proposals as they may place an additional burden on TDD bidders. *From responses to the Auction Rules Consultation:* One respondent stated that the 'restricted block' condition does not solve the interference issues between FDD and TDD equipment using the edge blocks.	
Reduction of mobile station in-band power to 18dBm/MHz	*From responses to the Discussion Document:* Arqiva, Nokia Siemens, O2 and a confidential response felt that mobile station in-band power should be reduced to 18dBm/MHz. Motorola did not support the suggestion. Samsung considered that there was no meaningful benefit in reducing the mobile station power, and the WiMAX Forum felt there was insufficient evidence for a reduction in the restricted block base station power. The UMTS Forum called for the potential impact of such a reduction on LTE to be considered. BT raised concerns about unnecessary burdens being places on LTE/WiMAX. Ericsson and Qualcomm felt that 24dBm/MHz would be appropriate, with Ericsson suggesting that a higher limit could be used in 5 MHz. Intel felt 20-24dBm/MHz may be more appropriate for WiMAX. Intellect and Nortel commented that power limits should be defined to be technology neutral, through the use of "power per bandwidth" rather than spectral density. T-Mobile considered that the mobile station power be specified as 24dBm/MHz for the full transmit bandwidth and blocks between FDD downlink and TDD should be guard bands restricted to downlink only. Urban WiMAX raised some concerns with the proposals.	

Technical licence conditions (use of spectrum masks or spectrum usage rights (SURs))

Issue raised	Comments	Ofcom's response
Use of SURs or spectrum masks	*From responses to the December 2006 Consultation:* BAA, the BBC, BT, GSA, Intellect, Motorola, the Nomad Forum, Nortel, O2, Orange, Samsung, T-Mobile, Vodafone and a confidential response preferred spectrum masks. GSA, Siemens and the UMTS Forum favoured the use of international standards. Ericsson considered a move away from the current proven approach to interference control based on international standards and agreements potentially misguided. David Hall Systems, Inquam Broadband and Intellect preferred a SUR approach, although Intellect did note that SURs still required substantial further work. Arqiva did not express a preference but did call for certainty ahead of the auction and the use of a method which does not introduce undue delay into the award. Intel requested that SURs be investigated more fully and only considered for the 2.6 GHz award if it did not delay the award. Nokia was in favour of conventional power limits until an SUR scheme based on PFD was agreed by the ECC. Qualcomm supported an approach based on standards and CEPT studies. *From responses to the Discussion Document:* Arqiva, BT, the Nomad Forum and O2 supported the decision not to use SURs Ericsson believed that the move away from the current approach to dealing with interference to spectrum masks would be misguided. Motorola commented that that work in international groups such as SE42 may impact the design but should not delay the overall award process. A confidential response supported the use of masks but wanted these to be based on the 3GPP standard.	As set out in the Discussion Document and in Section 6 of this Statement, we have decided to use spectrum masks, not SURs, in the context of this award.
Details of spectrum masks	*From responses to the December 2006 Consultation:* Motorola, Nortel, Qualcomm, Siemens,	The masks for the 2.6 GHz and 2010 MHz band are described in Section 6 of the Statement and the underlying

	T-Mobile and the UMTS Forum commented that the masks were based on 5 MHz spectrum blocks, and that LTE and WiMAX may need 10 MHz or more. Motorola specifically suggested that the ETSI masks (in particular EN 302 544) be accommodated in the masks. T-Mobile also provided detailed comments on the masks, with their response setting these out fully. The UMTS Forum raised concerns about the need for additional filters. BT supported the principle of using spectrum masks, but had suggested that the in-band power constraints could be relaxed. Ercisson believed that the masks were not sufficient in terms of width and that further mitigation was still required. H3G noted that some masks were more relaxed than the 3GPP specifications. One respondent believed the masks proposed were suitable for WiMAX mobile terminals and had no particular concerns regarding the base station masks. Nokia noted that the proposed masks would need to be reviewed when LTE masks are more stable. O2 believed that the proposed restrictions would protect adjacent operations. Orange had various concerns with the proposed masks, with details provided in their response. Vodafone did not want any additional requirements to be imposed, so as to enable economies of scale. The WiMAX Forum supported masks that were compatible with its masks. *From responses to the Discussion Document:* Nokia Siemens commented that the masks should be based on the work done by CEPT SE42. A confidential response expressed concerns over the analysis regarding the spectrum masks and claimed that they did not offer protection from neighbours. *From responses to the Auction Rules Consultation:* T-Mobile agreed with the proposal to use CEPT Block Edge Emission limits, and called for out of band masks to be	analysis is set out in Section 5.

	clearly defined in the Information Memorandum for standard and restricted blocks, with the elimination of associated ambiguities. One respondent wanted the masks to be based on the 3GPP standard. Motorola provided some technical points on the block edge masks.	
Details of SURs	*From responses to the December 2006 Consultation:* The BBC felt that the SURs were appropriate to UMTS but not to WiMAX or PMSE, and thought it was difficult to verify if an adjacent user was violating SURs. BT and GSA had a variety of concerns with the method used to calculate the SURs. David Hall Systems noted that the formulae including in the December 2006 Consultation appeared to be different to those given in the SUR consultation document. H3G believed that the SURs as laid out in the December 2006 Consultation were unworkable as they were not sufficiently specified and based on inappropriate assumptions. Intel believed the SURs needed to be investigated more fully and validated before implementation. O2 had various concerns with the SURs, with details given in their submission. Orange commented that it felt that there were a number of problems with a move to SURs and provided a detailed analysis in an annex to their response. Qualcomm considered that it was too early in the development of SURs to use them, and that their use should be delayed until the outcome of CEPT work. Siemens had concerns with a number of factors and considered that SURs could be an improvement on masks but that it was too early to use them for this award. T-Mobile expressed their view of the need for a clear legislative definition of rights, and identified a number of problems with the SURs as set out in the December 2006 Consultation. The UMTS Forum felt that the SUR methodology required further work and that the SUR parameters included in	As set out in the Discussion Document and in Section 6 of this Statement, we have decided to use spectrum masks, not SURs, in the context of this award.

	the consultation were not appropriate to ensure optimal use of spectrum and coexistence between users. Vodafone requested clarification on the regulatory framework for SURs, including the enforcement of rights.	
Licence exemption and interface requirement	*From responses to the December 2006 Consultation:* BT, T-Mobile and Vodafone requested clarification of whether terminals would be licence-exempt before the award, with BT expressing a preference for terminal exemption. T-Mobile and Vodafone requested draft Interface Requirements (IR) published for consultation. *From responses to the Discussion Document:* Nokia Siemens felt that terminals should be licence exempt. Motorola requested clarification on licence exemption of terminals and first stage backhaul.	In Section 8 of this Statement, we set out our policy to exempt from licensing terminals that comply with relevant technical requirements where licensees request it.

Other issues (including the 2012 Olympic Games)

Issue raised	Comments	Ofcom's response
2012 Olympic Games	*From responses to the December 2006 Consultation:* The BBC stated the need to access bands where equipment is available and had concerns about bands only being available for the 2 weeks of the Games. *From responses to the Discussion Document:* Arqiva, while recognising that the question of spectrum availability during the 2012 Olympic Games was a Government concern rather than an Ofcom issue, requested clarity on the process that Ofcom would expect to adopt if spectrum were required. BT felt that there was no requirement to specify a licence condition on this issue. SPMF questioned why Ofcom was not looking to include a specific condition requiring licence holders to free up spectrum for PMSE during the 2012 Olympic Games.	We have decided that the licences for the 2.6 GHz and 2010 MHz bands will not include any particular provisions in respect of the London 2012 Olympic Games. Please see Section 4 (Non-technical conditions) of this Statement for more information.
Infrastructure sharing	*From responses to the December 2006 Consultation:* The GSA and Siemens suggested that Ofcom should consider allowing	We do not consider that it is necessary to address this point as part of the provisions for this award and note that no party with plans to use the available

	infrastructure sharing where two licensees could flexibly share spectrum.	spectrum has asked for such provisions.

Annex 2

Impact Assessment

Introduction

A2.1 The analysis presented in this annex represents an impact assessment, as defined in section 7 of the Communications Act 2003 (the Act).

A2.2 This Impact Assessment provides a summary of our analysis of the key issues covered by this Statement. In so doing, it also covers the issues raised in the previous Impact Assessments in the December 2006 Consultation, the Discussion Document of August 2007 and the Auction Rules Consultation of December 2007. The IA also considers comments received in response to our Auction Rules Consultation and sets out the changes we have made in the light of these comments.

A2.3 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 our activities. However, as a matter of policy we are 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

A2.4 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.

A2.5 We recognise that some additional value to society could result from the provision of broadband services to rural areas. However we believe that subsidising outputs (i.e. the use of broadband by end users) is likely to lead to less distortion than intervening directly in spectrum market. Moreover there are several precedents in the UK for using subsidies to promote the spread of fixed broadband services, e.g. by regional development agencies. We therefore consider that the value of the spectrum for private users should be a good proxy for the public or social value of the spectrum.

A2.6 We consider that, overall, our decision to award this spectrum via auction on a technology neutral basis is the approach most likely to secure the greatest benefit for consumers. Our research has shown that awarding this spectrum is likely to increase competition, promote the provision of new services and create considerable benefits for consumer welfare.

Our duties and policy objectives

A2.7 Our duties and objectives are set out in Section 3 in so far as they relate to our overall approach to the award, and in Section 7 in so far as they relate to auction design. Our overall approach is designed to meet our principal duty to further the interests of consumers, where appropriate by promoting competition. In fulfilling this principal duty, we consider that our duties to secure optimal use of spectrum, promote innovation, and secure the availability of a wide range of electronic communications services are also of particular significance. We consider that the high level objective of promoting an outcome that awards spectrum to those that can create greatest value from its use, irrespective of technology or use, is compatible with these duties in the case of this award.

A2.8 In light of these duties and objectives, we have taken decisions on the award with a view to providing the relevant degree of flexibility for the market to determine optimal use. We consider that the available spectrum should be awarded as soon as practicable. The proposed awards could therefore take place in 2008.

A2.9 We consider that regulatory intervention is necessary to define and implement appropriate processes to authorise use of the available spectrum.

A2.10 In light of the above duties and objectives, we have assessed 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 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;
- what auctions designs are appropriate for the available bands – sealed bid or open multi-round processes and detailed associated processes;
- what the relevant licensing conditions should be, including those in respect of roll-out obligations, tradability and tenure; and
- whether it would be necessary to intervene directly in the award process to promote competition.

Choice of assignment mechanism

A2.11 This spectrum could be assigned in a variety of ways “first come, first served”, comparative selection (commonly referred to as a beauty contest) and an auction. Comparative selection was ruled out during the SFR:IP consultation process. The other two options are considered below.

Option	Advantages	Disadvantages
First come first served	Quick and inexpensive way to assign spectrum	If there is excess demand for the spectrum, this is unlikely to award it to those who value it most, and is therefore unlikely to secure efficient use of the spectrum.
Comparative selection	Enables bids to be judged against whatever criteria are considered appropriate to fulfil our duties including social value (however we consider that such considerations are unlikely to be significant for potential uses of the 2.6 GHz band).	Bidders and Ofcom will incur costs in participating in and running the comparative selection process, however these are likely to be small in relation to the value of the spectrum. We have to evaluate bids against a set of criteria and it is not certain that spectrum will be assigned to those who value it the most. This also carries the risk of regulatory failure both in setting evaluation criteria and measuring against them.
Auction	Assigns the spectrum to those who value it most, therefore promotes the efficient use of the spectrum.	Bidders and Ofcom will incur transactions costs in participating in and running the auction, however these are likely to be small in relation to the value of the spectrum.

A2.12 Our decision 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 award

A2.13 We have considered two options for the timing of this award, as summarised in the table below:

- whether to award the spectrum as soon as possible, given that the spectrum is available for use and we have received credible expressions of interest for access to the spectrum now; and

- whether to delay the award because of uncertainties, particularly mobile spectrum liberalisation, may affect one particular group of bidders (MNOs) and lead to an inefficient outcome if the spectrum is awarded now.

Option	Advantages	Disadvantages
Award the spectrum as soon as possible	The spectrum is currently underused and there is demand to use the spectrum now, therefore awarding the spectrum will generate benefits for service providers and consumers. The firms who have indicated that they would like to use the spectrum now would be new providers of mobile broadband services. Hence	Uncertainty over 2G liberalisation might impact on valuations on 2.6 GHz spectrum and lead to a less efficient allocation than if the award were delayed to a point when there was no longer uncertainty over 2G liberalisation. However, our analysis suggests that uncertainty over 2G liberalisation is

	consumers are likely to enjoy competition benefits as a result of entry into the market. Innovation may be greater for two reasons. Firstly it appears likely that companies will offer services that are not currently being provided. Secondly, competition from different technology platforms may spur both incumbents and entrants to greater innovation leading to dynamic efficiencies. Awarding the spectrum now may enable firms to take advantage of a window of opportunity to enter the mobile market and provide mobile broadband services. This may become more difficult if the award is delayed so that incumbents have developed further their own mobile broadband services, making it difficult for entrants to overcome the incumbents' first mover advantages.	unlikely to be the dominant source of uncertainty in 2.6 GHz valuations when compared with the aggregate effect of other sources of uncertainty such as customer demand, technology and other regulatory developments. Moreover, though we agree that there are some links between 2G spectrum and 2.6 GHz, they are unlikely to be close substitutes for each other for the reasons explained in section 3. A third mitigating factor is that trading could adjust, at least partially, for inefficiency in the auction outcome.
Award the centre range 2570-2620 MHz as soon as practical and delay the award of the remaining 140 MHz	Some spectrum is released to satisfy the immediate demand for the spectrum, while the remaining 140 MHz is held back for award at a time when there is greater certainty over the future holdings of 2G spectrum, thereby allowing the award of this 140 MHz to take place against at a time when bidders might be able to make better informed valuations and, as a result, leading to a more efficient outcome...	Releasing 50 MHz is likely to be sufficient to accommodate only one entrant. In this case, the supply of spectrum will be artificially restricted, which could inflate prices and lead to a risk of "hold-up" strategies whereby other bidders force up the price that has to be paid by the winning bidder. Other potential users of the spectrum will have to face a delay in getting access to the remaining 140 MHz. Hence the benefits which could accrue if those firms gained access to the spectrum as soon as possible will be lost. There would be significant aggregation and substitution risks arising from awarding two parts of the band at different times. As noted above, our analysis suggests that the impact of a delay on the efficiency in the allocation of the remaining 140 MHz will be limited - uncertainty over 2G spectrum liberalisation is not the dominant source of uncertainty. Moreover,

		trading can mitigate inefficiencies in the primary allocation.

A2.14 Our decision is to award the spectrum as soon as practicable because: the spectrum is underused; there is demand to use the spectrum now and the evidence for delaying the award is insufficient to justify departing from our standard approach of making un-used or underused spectrum quickly available when there is demand for it. In particular, we consider that there is a low risk that the ultimate use of 2.6 GHz spectrum will be rendered inefficient on account uncertainties over mobile spectrum liberalisation that exist at present. Moreover, a decision to delay the award would certainly deny access to prospective new entrants in the immediate future and may deny them access to the market entirely if the delay caused a window of opportunity to close. The risks of delay leading to an inefficient outcome are much greater than the risks that proceeding now would do so. Our reasoning for these conclusions is given in greater detail in section 3 of this Statement.

Technology Neutrality

A2.15 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	Demand assessment suggests that a range of different technologies and services wish to use this spectrum. The potential efficiency of the auction is maximised by allowing bidders the option of using the technology and service with which they can generate the greatest value. Technology specific restrictions carry a material risk of regulatory failure as the regulator has to make decisions over choice of technology and service which could turn out to be materially sub-optimal in future. Consistent with the Framework Directive.	A technology specific approach could allow technical usage rights to be defined in such a way reduces the risk of interference between adjacent users of this specific technology. However, these risks can be mitigated by the adoption of suitable technical licence conditions.
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 us to choose one or more technologies or services. It could also require us 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. We have 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 Market-led harmonisation benefits can be achieved anyway through the decisions we have made on spectrum packaging.

A2.16 We have decided to use a technology and service neutral approach to award this spectrum because the market is more likely to drive the most efficient use of the spectrum. Our rationale for this decision is explained in greater detail in section 4 of this Statement.

Packaging options

A2.17 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 individual (unpaired) lots. In the 2010-2025 MHz band, the issue is the size (and therefore number) of the lots which should be offered. 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. We do not have to predetermine the optimum package size that bidders may require. Consistent with outcome of European regulatory work on technical conditions.	None identified.
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	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.

	packages to be bid on could eliminate the need for package bidding entirely. It could also potentially reduce the number of guard bands required.	
2.6 GHz - band plan, division between paired and unpaired lots		
Auction decides split, 120 MHz duplex spacing maintained	Market demand determines split of spectrum between paired and unpaired uses. Allowing this flexibility will support the objective of seeking to allocate the spectrum to those that can create greatest value form its use.	Introduces one extra potential adjacency between paired and unpaired spectrum, requiring one more 5 MHz restricted block. However, this would only happen if the resulting allocation was of higher value, as determined by bids submitted in the auction (i.e. it would only occur if this was economically efficient). Potential for interference from TDD terminals into FDD terminals could reduce the utility of FDD spectrum (on the basis that the market would not support UK-specific handsets). However, the analysis summarised in section 5 indicates that this should not be a material issue.
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.	It is likely that an alternative duplex spacing would add significantly to equipment costs.
CEPT band plan - 2x70 MHz paired, 50 MHz unpaired	Would guarantee benefits of harmonisation in terms of European equipment market and roaming benefits if all of Europe follows CEPT band plan. Minimises risk of interference (and consumer detriment) from TDD mobile terminals transmitting in parts of the band being used for FDD downlink in the UK.	Risks a material inefficiency in the division of spectrum between paired and unpaired by not allowing flexibility. The analysis summarised in section 5 indicates that risk of terminal to terminal interference should not be a material issue.
2010-2025 MHz - size and number of lots		
One single 15 MHz lot	Fits the expected needs of users well. Allows potential users requiring less than 15 MHz to agree how they could coordinate to use the spectrum, rather than us 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.

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 we will have to impose as a default very restrictive usage rights in order to allow separate uses to coexist. This consideration is compounded by the requirement to avoid interference into possible future CGC operation below 2010 MHz which means that the bottom 5 MHz of this band may have restricted use on practice (as explained in section 5)
Both bands – Geographical extent of lots		
UK-wide lots	It is more spectrally efficient to allocate spectrum across the UK as a whole rather than at a more granular level 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	Potential bidders for spectrum at a sub-UK level will find it difficult to participate in the auction
Regional lots	Would allow us to satisfy demands for spectrum on a regional basis.	Difficult for the regulator to determine the appropriate geographical areas for non-UK licences Unclear 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. Difficult to rebuild a national use from regionally awarded licences. We received no firm expressions of interest in regional lots.

A2.18 Our conclusions, which are explained in more detail in section 5 of this Statement, are as follows:

- We consider 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.

- The band plan for 2.6 GHz in terms of the split between paired and unpaired spectrum should be determined in the auction, whilst the 120 MHz duplex spacing specified in the CEPT band plan is maintained. This will still allow the

benefits of harmonisation (in terms of scale of equipment market and roaming) to be accessed, and that there are considerable benefits to giving the market the flexibility to determine the division of the spectrum between paired and unpaired.

- It is better to package the 2010-2025 MHz band as one single lot. The alternative of offering lots of 5 MHz would mean that we would have to set unduly restrictive rights on this spectrum, severely restricting the services that could be offered.

- We consider that the spectrum should be offered on a UK-wide basis for both bands.

Auction design options

Linkage between 2010 and 2.6 GHz

A2.19 We considered the option of separating the award of 2010-2025 MHz versus linking it to 2.6 GHz.

A2.20 These options are discussed in the table below.

Option	Advantages	Disadvantages
Link this award to 2.6 GHz rather than separate them	This spectrum may be a substitute for 2.6 GHz for some uses and bidders will face substitution risks if the awards are separated. The 2010 MHz band is not currently used and so awarding this band as soon as possible is likely to be compatible with our duties. Given our decision to award the 2.6 GHz band as soon as possible, there are significant cost and practical advantages in holding that awards as part of the same process.	Linking the awards could create opportunities for strategic behaviour (e.g. parking demand on the 2010 lot during the primary bid rounds in the Principal Stage of the auction). However, the risk of such behaviour leading to a sub-optimal outcome is low.

A2.21 We have decided to link the award of this spectrum to the 2.6 GHz award. The efficiency advantages outweigh the minor risks of enabling a minor opportunity strategic bidding behaviour.

Key choices

A2.22 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 key design options set out in the table below.

Option	Advantages	Disadvantages
Simultaneous or sequential award of lots		
Simultaneous award	Allows bidders to manage aggregation and substitution risk	

	across lots.	
Sequential award		Introduces significant substitution risks and aggregation risks given the substitutability and complementarity of the available lots.
Single round (sealed bid) or multiple rounds (ascending bids)		
Single round (sealed bid)	Simpler to administer May encourage participation where there are significant bidder asymmetries and related concerns about the level of competition in the auction.	Does not enable bidders to gain information on lot values from other bidder's behaviour. Bidders unable to switch their demand to different lots in response to changes in relative prices Bidders could be required to submit a large number of bids in respect of all the packages they might be interested in.
Multiple rounds (ascending bids)	Bidders are able to observe aggregate demand over the course of multiple rounds, thereby reducing common value uncertainty. Allows bidders to switch their demand to different lots in response to changes in relative prices, enabling them to avoid substitution risks.	More involved than a single round award (but the multi-round process in easy for bidders to understand)
Separate bids on individual lots or combinatorial (package) bidding		
Separate bids on individual lots	Allows bidders considerable flexibility to shift demand across lots in response to changes in prices, and provides some opportunity for bidders to monitor their aggregation risks.	Bidders lack certainty over whether, and at what price, they might win complementary lots. As demand for lots diminishes towards the end of an auction, there is a risk that bidders may become stranded with unwanted lots.
Combinatorial (package) bidding	As long as bidders bid in line with their preferences, there is no aggregation risk of being stranded with unwanted lots.	Risk exists that smaller bidders, who might want only individual lots, may be unable to adequately coordinate their demand. May be an incentive for individual small bidders in any ad hoc coalition which forms to bid untruthfully to seek to "free ride"

		on other members (although this "free-rider" risk is largely addressed in this auction design by the use of generic lots during a clock phase of the auction, by the use of a second price rule which encourages bidders to bid their full value in the supplementary bid round and by our decision not to release information on individual bids).
Generic or specific lots		
Generic lots	The generic lot approach makes it much easier to allow bidder demand to drive the allocation between paired and unpaired spectrum and do so in a way that is both less complex than a specific lot approach and likely to lead to a more efficient outcome. Particularly appropriate where bidders are likely to be interested in packages of more than one lot as the auctioneer can guarantee that most (if not all) bidders will receive contiguous frequencies.	Requires follow-up process to assign specific spectrum packages
Specific lots	Enables bidders to accurately express the differences in valuations between lots, which is appropriate when there is a material difference in value between lots	Significantly more complex than award with generic lots. Much greater risk of award leading to inefficient spectrum packaging.
Clock prices or bidder nominated prices		
Clock prices	Simplifies process for bidders - 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. Reduces complexity of both the auction rules and the algorithms used to establish the identity of the (provisional) winning bids at the end of each round and the starting prices for individual lots in the next round. Reduction in complexity particularly helpful for smaller bidders.	

Bidder nominated prices		More complex to administer particularly in the context of package bidding and more complex for participants

A2.23 The above factors lie behind our decision to use simultaneous, multiple round ascending auction (SMRA) process with rising clock prices and combinatorial bidding based on the use of generic lots. Further explanation is given in section 7 of this Statement.

A2.24 When using generic lots there is a need for a subsequent process to convert the generic lots into assignments at specific frequencies. The options for how this subsequent process is conducted are covered in the table below.

Option	**Advantages**	**Disadvantages**
Competitive or administrative assignment stage		
Competitive bidding	Allows bidders to express differences in the value of where in the band lots are located, and is relatively quick, simple and cheap to operate.	
Administrative approach	Simplest approach if bidders are indifferent to where they are located in the band. However, this is unlikely to be the case.	Unlikely to deliver an efficient allocation if bidders place different values on different frequency assignments as administrative process cannot capture this.
Single round, sealed bid process or open multi-round process		
Single round, sealed bid process	Simpler process. Appropriate when there is little difference in the value of lots at different frequencies.	Does not enable a process of price discovery through bidder's ability to observe behaviour of others in a multi-round process
Open multi-round process	Can enable a process of price discovery through bidder's ability to observe behaviour of others from round to round.	Significantly more complex to implement and of limited benefit since the differences in value between lots will be specific to the bidder with little common value uncertainty. Moreover, the analysis in section 5 of this Statement indicates that there should not be large differences in the values of lots at different frequencies.

A2.25 We have decided to use a competitive assignment stage as bidders are expected to place some difference in value between lots at different frequencies. However, a single stage sealed bid process is appropriate since these differences are not likely to be large, nor is there significant common value uncertainty in this respect.

Detailed options relating to auction design rules and procedures

A2.26 In the Discussion Document and the Auctions Rules Consultation, we considered some of the more detailed options relating to auction design, rules and procedures. Some of these options were related to new proposals we made, while consideration of other options was prompted by responses to the December 2006 Consultation and the Discussion Document. The key points on each of these options are covered in table form below.

Extra bidding options

Option	Advantages	Disadvantages
Whether or not to allow bidders for a split assignment of individual (unpaired) lots to specify where each part of the split award is located	Allowing this extra bidding option would enable bidders to express their preferences more exactly for unpaired lots in the upper and lower unpaired areas	Allowing this option would require the creation of two types of unpaired lot which would add considerable complexity to the auction design. In turn, greater complexity could increase the risk that bidders do not fully express their preferences for different combinations of spectrum, potentially weakening the efficiency of the award. Could make it more difficult to fit combinations of bids into the available spectrum when there are split supplementary bids and could therefore increase the chances of having unsold spectrum. Differences in value of unpaired spectrum between the upper and central areas are likely to be sufficiently small that they can be treated as one category of generic lots

Whether or not to allow paired spectrum bidders to make bids contingent on individual (unpaired) lots being awarded in top part of band	Allowing this extra bidding option would in principle allow the auction to determine the most efficient allocation of the spectrum given bidders' assessment of the impact of blocking between FDD and TDD terminals in the upper part of the band.	The technical analysis discussed in Section 5 indicates that the impact of blocking (terminal to terminal interference) is unlikely to be significant. Therefore, there is limited risk that not allowing contingent bids would lead to an inefficient award. Allowing contingent bids creates a risk that bidders could bid less than their true values (for paired/FDD spectrum) in order to drive an outcome that restricts unpaired use in the upper part of the band. This, in turn, creates a risk that the scope for the award to deliver innovation and new competition could be reduced (because of a reduced scope for unpaired/TDD users to access spectrum) Introduces additional complexity for bidders which can also lead to inefficient outcomes of the award if bidders do not fully express their contingent preferences for packages in the award.
Whether or not to allow bidders in the Assignment Stage to make bids contingent on who occupies neighbouring spectrum	Allowing this option would let bidders express how their valuations would be affected by the externalities between them and their neighbours	Including this facility would create opportunities for some bidders to influence which spectrum their competitors would receive. This creates undue risks to the optimal use of the spectrum and is in itself a potential competition issue This change would significantly increase the complexity of the auction.

A2.27 Our conclusion for each of these options is that the costs significantly outweigh the benefits and, therefore, we have not implemented these changes.

Information release

Option	Advantages	Disadvantages
During the primary bid rounds		
1. Aggregate demand for each category of lot only	Allows bidders to track demand for different categories of lot and so aid in price discovery and reduction of common value uncertainty. By not releasing information on individual bids it will become very difficult for bidders to bid strategically in a way designed to reduce competition.	Benefits from reducing common value uncertainty might not be as high as providing more information on bids.
2. Anonymised bids	Aids in price discovery to a	There is an increased risk of

without labels	greater degree than simply publishing aggregate demand	bidders being able to bid strategically, and coordinate through signalling, so as to reduce competition.
3. Anonymised bids which are labelled consistently	Labelling bids would enable participants to track the actions of bidders round by round on an anonymised basis, so they could understand better the behaviour of individual bidders	This would further increase the risk of strategic bidding behaviour.
At the end of the Principal Stage		
Whether or not to release details of all Principal Stage bids	Releasing these details enables bidders to check the winner determination It would also provide bidders with additional information to draw on when explaining the outcome of the award up to the Assignment Stage to financial decision makers	Releasing this information may enable bidders to work out other bidders' budget constraints and bid strategically on this basis Information on Principal Stage bids should not be of any use to bidders in developing their valuations for the purpose of the Assignment Stage This information is also unlikely to be needed to inform a Board decision of the bidder, as the bidder will have already decided to pay at least the base price
Whether or not to release the base price for each bidder (in addition to the identities of winning bidders and the packages they won)	Releasing this information would help to manage communication to bidders and the public Doing so is also unlikely to introduce risks of strategic bidding because base prices should have no impact on bidding strategies in the Assignment Stage	Releasing the information creates a small (and probably manageable) risk of a degree of confusion amongst followers of the auction's progress because the final prices paid may be higher than the base prices
In the Assignment Stage		
Whether or not to provide bidders with full bid options (i.e. all possible combinations of how winning bids could be accommodated)	Providing bidders with full bid options removes the small risk that some would be unable to determine this information for themselves	Providing this information would not increase the amount of information available to bidders

A2.28 With regard to the information release options outlined above, we have decided:

- to release only aggregate demand for spectrum during the primary bid rounds;
- not to release details of all Principal Stage bids at the end of the Principal Stage;

- to release the base price for each bidder (in addition to the identities of winning bidders and the packages they won) at the end of the Principal Stage; and

- to provide bidders with information on full bid options in the Assignment Stage.

Switching rules

Option	Advantages	Disadvantages
Whether (or not) to prevent switching between paired and individual (unpaired) lots in the supplementary bids round	It is possible that switching may create the opportunity for undesirable strategic behaviour to hide the nature of demand during the primary bid rounds.	Likelihood of bidder using supplementary bid rounds to hide demand is low as doing so would create risk that bidder would win unwanted spectrum. There would appear to be very little to be gained from such a strategy (and low risk of it leading to an inefficient outcome) because of the flexibility in allocation between paired and unpaired lots. Risk that not allowing switching may prevent bidders who bid truthfully from expressing full range of preferences

A2.29 We have decided not to restrict switching in the supplementary bids round.

Activity rules

Option	Advantages	Disadvantages
1. Quantity-based activity rule	Provides support for price discovery and for the reduction of common value uncertainty by making the total amount of spectrum a bidder can bid on in a given round dependent on their activity in previous rounds.	There is a risk that bidders ability to submit a full range of bids in the supplementary bids round could become overly constrained should the ratio of eligibility points between lots not be broadly reflective of the relative value of the lots (although this should not be a problem in the 2.6 GHz award because the fungible allocation between paired and unpaired lots).

2. Value-based activity rule	Encourages bidders to bid consistently throughout the auction with regards to the value they attach to each lot. More effective than a quantity based activity rule in promoting truthful bidding.	More relevant for awards where the relative value of different lots might diverge from the ratio of the eligibility points associated with different categories of lot during the auction. This is unlikely to be the case in the 2.6 GHz band. Introduces an increased level of complexity: bidders may find it more challenging to explain to their internal stakeholders (e.g. their Boards).

A2.30 We have decided to use a quantity-based activity rule for this award.

Deposits

Option	Advantages	Disadvantages
Level of deposits		
1. Deposits to be topped up to 100% throughout Principal and Assignment Stages	Provides a disincentive for default.	100% deposit could be difficult for bidders to raise in advance of acquiring the asset in high value auctions.
2. Deposits to be topped up to 100% of base price at end of Principal Stage and for Assignment Stage, but deposit requirement set at a lower level (less than or equal to 50% with Ofcom retaining flexibility to vary the amount as the primary rounds progress) during primary and supplementary bids rounds	Provides a disincentive for default, especially at the end of the Principal Stage and Assignment Stage when default could be most damaging to the award process. Setting the deposit level at less than or equal to 50% with Ofcom having discretion to vary the level provides flexibility to adjust the level of deposits based on the clock prices.	If the deposit level was fixed at 50%: bidders could still find it difficult to raise large deposits towards the end of the auction (when bid values might be high).

3. Deposits to be topped up to less than 100% of base price at end of Principal Stage and for Assignment Stage, but deposit requirement set at a lower level (less than or equal to 50% with Ofcom retaining flexibility to vary) during primary and supplementary bids rounds	Provides a disincentive for default, but not as effectively as Options 1 and 2. Setting the deposit level at less than or equal to 50% with Ofcom having discretion to vary the level provides flexibility to adjust the level of deposits based on the clock prices.	If the winning bidders at the end of the Principal Stage do not have to put 100% of the base price on deposit, there is an increased risk of default. Moreover, the requirement for the 100% deposit at this point imposes little additional financial burden as it only applies to winning bidders and these bidders will anyway be required to pay for their licences as soon as the Assignment Stage is completed. If the deposit level was fixed at 50%: bidders could still find it difficult to raise large deposits towards the end of the auction (when bid values are high).
Timing of requests for deposits		
1. Employ a fixed rule for when deposits are increased based on the ratio of existing deposits to prices	Employing such a rule would provide bidders with sufficient information to prepare for deposit top-ups during the auction.	May result in an unnecessarily high number of top-ups which could disrupt the efficient running of the auction and place an additional administrative burden on bidders
2. No fixed rule and Ofcom to request top-ups from time to time	Would potentially reduce the overall number of requests for top-ups and therefore, the administrative burden on bidders.	May not provide sufficient advance warning for bidders to prepare.
3. No fixed rule and Ofcom to provide guidance on indicative trigger levels in the Information pack provided for bidders at the time of the award.	Employing such a rule would provide bidders with sufficient information to prepare for deposit top-ups during the auction. Would potentially reduce the overall number of requests for top-ups and therefore, the administrative burden on bidders.	

A2.31 We have decided:

- to set the level at which deposits should be topped up as 100% of base price at the end of the Principal Stage (for bidders that will be wining bidders) and 100% of highest bid in the Assignment Stage, and at less than or equal to 50% during

primary and supplementary bids rounds, with Ofcom retaining flexibility to vary this level; and

- to employ no fixed rule as to when deposits should be topped up but instead to provide guidance on indicative trigger levels in the Information pack provided for bidders before the award.

Bidder association

Option	Advantages	Disadvantages
Whether to allow an exemption to the restriction on the flow of confidential information between bidders for the purpose of negotiating a national roaming agreement	Providing an exemption may enable bidders to refine their valuation by having better information on roaming agreements and charges.	Allowing an exemption creates the risk that the exchange of information between applicants may affect their decisions in relation to the award and could materially affect the outcome of the award process. If we do not specifically provide an exemption, it is still possible in principle for two parties to hold discussions without breaching activity rules, but we need to retain the scope to apply penalties depending on the exact nature of information exchanged.
Whether, on application, to allow entities holding a material interest in one or more bidders to be excluded from bidder groups and such that they may participate in at most one bidder group	Allowing an entity to be excluded from a bidder group of which it would otherwise automatically be a part removes barriers for it to participate in the award, increasing competition, whilst the conditions associated with the exclusion should maintain the integrity of the auction process. For example: o the party should not hold more than 50% of the share in the applicant; o the party should not have the right to appoint or remove a majority of the applicant's board of directors. Conversely, not allowing entities to be so excluded could have a negative impact on competition by limiting the ability of potential bidders to raise funding.	Allowing entities to be excluded from bidder groups of which they would otherwise automatically be a part could create opportunities for strategic behaviour. However, the procedure has been carefully designed to mitigate the risk and Ofcom will retain discretion to judge any case on its merits (and so guard against abuse of this facility).

A2.32 We have decided:

- not to allow an exemption to the restriction on the flow of confidential information between bidders for the purpose of negotiating a national roaming agreement; and

- to allow entities holding a material interest in more than one bidder to apply to be excluded from applicant or bidder groups and participate in at most one bidder group subject to certain conditions as laid out in the draft regulations.

Spectrum cap

Option	Advantages	Disadvantages
Impose no restrictions	Bidders can express their demand for every quantity of spectrum that they might require on the grounds that there may be legitimate business cases for acquiring very large amounts of spectrum.	It is possible that a bidder could try to acquire the entire spectrum with the intent of excluding other bidders from winning. In mitigation, the potential cost of buying the entire spectrum, given the large amount available, makes this unlikely. Alternatively, this scenario might happen if there was very weak demand for the spectrum and one bidder could therefore outbid others for a large part of the spectrum. The cost of precluding this outcome would be low under these circumstances.
Impose a "strong" spectrum cap e.g. 60 MHz or even less	A tighter cap may allow more parties to win spectrum in the award.	A cap at or below 60 MHz could constrain bidders from efficient uses of the spectrum (we are aware of interest which exceeds this level). We would have 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 unlikely that we would know better than the market what the maximum level should be. There is no objective justification for seeking to engineer a particular industry structure through this award.
Impose a "safeguard" spectrum cap e.g. 80 MHz excluding restricted blocks	This guards against a low risk, but adverse scenario where one participant acquires all (or most) of the spectrum in order to exclude others. Although ex post competition powers can be used to address competition concerns, using these powers can be a lengthy process.	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 interested parties have indicated that they might want to acquire.

Given the large amount of spectrum available, the potential costs of delay could be high.

A2.33 We consider the choice between not introducing spectrum caps and setting a safeguard cap finely balanced. However we reject setting a low cap because of the potential for regulatory failure in setting the precise level of the caps.

A2.34 We have changed the detail of how the cap would operate from an overall cap of 90 MHz including any restricted use blocks, to a cap of 80 MHz excluding any restricted use blocks. We have made this change because the former rule would not have treated all bidders equally. While bidders for paired lots are not allocated restricted use blocks, bidders for individual (unpaired) lots are allocated a restricted use block (or two if they win a split allocation of individual lots). We consider that applying the cap only to fully usable spectrum (i.e. standard blocks with normal base station powers) is fairer. We note that the cap of 80 MHz of usable spectrum still carries a very low risk of excluding any legitimate aggregation of the spectrum.

Non-technical licence conditions

Roll-out obligations

A2.35 Section 4 of this Statement considers the case for including a roll-out obligation in detail.

Option	Advantages	Disadvantages
Do not include roll-out obligation in 2.6 GHz licences	Licensees are free to roll out their networks in accordance with market demand. Encourages new entry which is likely to provide competition and innovation benefits for consumers.	If service providers using 2.6 GHz do not roll out to 80% coverage, then, to the extent that there would be social value in wider roll-out, there may be a loss in social welfare. However, there is no evidence of that there would be significant social value (as opposed to private value) from use of this band. Even if there were significant social value to be gained, this would be more efficiently served by the use of direct subsidies, e.g. to target increased broadband take-up (as has been done in the past).
Include roll-out obligation in 2.6 GHz licences (to 80% coverage as in 2.1 GHz licences)	Ensures that networks at 2.6 GHz roll out to 80% coverage which could provide greater citizen and consumer benefits than a lower level of roll-out, but subject to the important caveat on not discouraging entry.	Significant risk that this could discourage entry if the efficient level of roll-out is, or might be, less than 80%. Imposes unnecessary restrictions on users of the 2.6 GHz which are unlikely to be economically efficient, or objectively justified.

A2.36 Our decision is that roll-out obligations should not be included within 2.6 GHz licences. We do not consider that it would be objectively justified to include roll-out

obligations in these licences. Neither do we consider that it would distort competition or be unduly discriminatory for the reasons explained in section 4 of the Statement.

Spectrum trading and licence tenure

A2.37 Our assessment of the options for tradability of the spectrum and licence tenure are presented below.

Option	Advantages	Disadvantages
Make the licences tradable	Promotes efficient use of the spectrum over time if the optimal allocation of the spectrum changes.	We consider that there is a low risk that spectrum use becomes fragmented, however we would have powers to intervene in the market for spectrum management reasons such as this.
Do not make the licences tradable	Avoids low risk of spectrum fragmentation.	Does not allow use of the spectrum to change if the optimal allocation of the spectrum changes over time.

A2.38 Our decision is that the licences should be made tradable and of indefinite duration, but with an initial term of 20 years then revocable on 5 years notice. The risks of making the band tradable appear very small, against substantial potential future benefits.

A2.39 We note that some stakeholders drew attention to the fact that 3G licences are currently not tradable and are of fixed duration. However, we do not consider that this gives rise to discrimination for the reasons explained in section 4 of the Statement.

Our decisions

A2.40 Having considered the advantages and disadvantages of the options, and in light of responses to the consultations, we have decided that:

- the spectrum should be awarded as soon as practicable;
- the spectrum should be packaged in 5 MHz lots with respect to the 2.6 GHz band and as one 15 MHz lot for the 2010 MHz band;
- the auction should be used to determine the split between paired and unpaired use in the 2.6 GHz band;
- the spectrum should be awarded on a UK wide basis (subject to any international restrictions);
- bidders should be subject to a “safeguard” spectrum cap to mitigate against risks of anti-competitive behaviour;
- the award of spectrum in the 2.6 GHz and 2010 MHz bands should be linked;
- a simultaneous, multiple round ascending auction process that allows combinatorial bidding should be used to award this spectrum;
- it is appropriate to use generic lots rather than specific lots; and

- the most appropriate SMRA auction format to use is a combinatorial clock auction with a competitive second phase;
- roll-out obligations should not be included within the licences;
- the spectrum should be tradable; and
- the licences should have an initial term of 20 years and be subject to revocation on five years notice at the expiry of the initial term.

Annex 3

Update on evidence of demand for the use of the 2.6 GHz band

A3.1 This Annex provides an overview of market developments that provide context for our consideration of potential future use of the 2.6 GHz band in the UK. It represents an update to the equivalent overview that we published in annex 12 of the Discussion Document. In particular, it covers:

- A summary of the position on expressions of interest in using the 2.6 GHz band in the UK [redacted];
- Recent developments and investments relating to the main candidate technologies for the 2.6 GHz band;
- Recent and upcoming awards of the 2.6 GHz band worldwide, and current use of the 2.6 GHz band where it has already been assigned; and
- General trends in demand for mobile broadband services.

A3.2 This Annex is not designed to provide an exhaustive compilation of all information that may be relevant to use of the 2.6 GHz band in the UK. Rather, its purpose is to illustrate from the body of information and anecdotal evidence that there is material interest in use of the band, and that this interest is reflected in the momentum building through industry and regulatory initiatives worldwide. The anecdotal evidence used for this purpose is drawn from third party forecasts, publicly available data and announcements from operators and equipment vendors,

A3.3 As set out in Paragraph A12.11 of the Discussion Document, a number of industry analysts and observers consider that, to provide the best possible opportunity for latent demand for mobile broadband services to materialise and to be met, the following factors need to be present at the same time:

- Network - speed, quality and coverage;
- Device - availability and penetration of data-optimised devices; and
- Services - data packaging (including price) and marketing.

A3.4 The first two of these factors rely on both the availability (and affordability) of network and end-user equipment and the availability of the spectrum to support these services. We therefore provide an overview of some of the significant developments that have taken place in respect of WiMAX and LTE technologies. This includes a consideration of the competitive effect that the availability of the new WiMAX technology appears to have had on the development of LTE. In reviewing recent developments, we also show:

a) in a general sense, that a range of industry members are devoting significant resources to the development of technologies and equipment for use at 2.6 GHz;

b) how these efforts are designed and likely to create innovative services for consumers; and

c) that several countries have awarded, and a number of others countries are preparing the award of, the 2.6 GHz band, and that where competitive awards of significant amounts of the band have taken place, new providers of wireless services have been able to gain access to spectrum.

A3.5 The third factor (Services) is related to the nature of services that are offered and general demand for mobile services. We provide updated information on forecasts for the underlying demand for mobile broadband services. In this context, the relevant forecasts relate to demand for mobile services of the type that are likely to be relevant to the use of the 2.6 GHz band (primarily mobile broadband services). The demand for these services could, of course, be met using a number of spectrum bands suitable for those uses in addition to the 2.6 GHz band, such as those currently held by the 3G MNOs. These forecasts do not consider the proportion of future demand that might be served through use of particular spectrum bands. An analysis of the possible distribution of traffic across different bands, including the 2.6 GHz band, would be highly complex and depend on a wide range of factors relating to market structure, operational considerations, availability of equipment etc. It would not be sensible or necessary for us to attempt such an analysis. The essential role of this information is to corroborate the view that there is a material and rapidly growing demand for the types of service that the 2.6 GHz band can be used to deliver and, therefore, to provide a sense-check that interest in use of the 2.6 GHz band is likely to be real.

Indication of interest in using the 2.6 GHz band in the UK

A3.6 We have received a number of indications of interest in using the 2.6 GHz band, both in the immediate future and in future years.

A3.7 ✂

A3.8 ✂

A3.9 ✂

A3.10 ✂

Recent developments and investments relating to the main candidate technologies for the 2.6 GHz band

A3.11 As set out in the Discussion Document, there are four main categories of services which could be of interest to prospective bidders and for which there could be significant demand:

i) advanced mobile telephony services using 3G technologies and their evolutions (UMTS FDD, HSPA and Long Term Evolution (LTE)) 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.

ii) broadband wireless services using WiMAX standards 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.

iii) 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.

iv) 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.

A3.12 The first three of these services can be grouped under the broad description of 'mobile broadband services' and are at the core of plans for use of the 2.6 GHz band from potential participants in the UK award as well as those of companies who gained access to the band in recent awards of the band internationally. By contrast, we have not received any clear expressions of interest to participate in the 2.6 GHz award for the provision of PMSE services, and recent awards of the band internationally have not led to access for PMSE.

A3.13 Accordingly, the remainder of this section summarises the current level of development and interest in WiMAX and LTE. As a further indication of the traction that these technologies have in the market, we provide some details on levels of recent or planned investments from equipment manufacturers and operators where this is available.

WiMAX

A3.14 WiMAX (Worldwide Interoperability for Microwave Access) is a new technology designed to provide a range wireless data services, based on the IEEE 802.16

standards. The IEEE standards[130] include a version developed for the provision of services to fixed or nomadic end-user terminals (802.16d) and a version developed for the provision of services to mobile end-user terminals, such as internet tablets or handsets (802.16e). The IEEE has also started work on further developments of the 802.16 family of standards and is preparing a new version for mobile services identified as 802.16m.

A3.15 A range of industry members have been and remain involved in the development of IEEE standards in the 802.16 family. Following on from the IEEE work, the WiMAX Forum[131] has been developing the detailed specification for WiMAX equipment and putting in place arrangements for certification of manufacturer equipment through controlled laboratories.[132] Its Board[133] includes companies such as AT&T, BT, Intel, KDDI, Motorola, Nokia, Samsung, Sprint Nextel, and the WiMAX Forum includes more than 525 companies from across the telecommunications industry (including designers and manufacturers of network equipment and chipsets, operators).[134]

A3.16 Like other industry-led standardisation bodies (such as 3GPP which is discussed later in this section in relation to LTE), the WiMAX Forum is driving the development of interoperable and compatible equipment by its members, with a view to facilitate economies of scale (through equipment design and common identification of spectrum bands for example). It also identifies as part of its goals plans to accelerate the introduction of equipment into the market.

A3.17 The computer industry conceived WiMAX primarily as a means for internet access and it offers scope for the principles of wide accessibility and openness of the internet to form part of mobile services. Sprint-Nextel in particular has outlined principles for such openness, in the form of new business models that allow a range of devices to receive services from a given network without necessarily being exclusively tied to that network.[135] Some industry commentators see in this a potential for consumers to have greater choice and increased scope to exercise that choice. The Economist, for example, has argued that such an open approach could have a significant impact on the mobile industry by facilitating new ways for consumers to gain access to mobile services.[136]

A3.18 In addition to the promotion of openness outlined above, WiMAX could provide a way to fill in broadband coverage gaps in rural areas and in developing countries, where the laying of cables may not be cost-effective.[137]

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[130] See http://www.ieee.org/portal/site and http://www.ieee802.org/16/
[131] http://www.wimaxforum.org/home/
[132] There are currently six laboratories (in China, Korea, Spain, the US and two in Taiwan) and this is expected to expand to nine with additions in Brazil, India and Japan (http://www.wimaxforum.org/news/pr/view?item_key=138e1080657b96738a279a92a2c3f8c0ce240d0a)
[133] http://www.wimaxforum.org/about/roster/
[134] The full list of current WiMAX Forum members is available at http://www.wimaxforum.org/about/Current_Members/
[135] See for example http://www.wimax-vision.com/newt/l/wimaxvision/article_view.html?artid=20017452978, http://www.xohm.com/our-company.html or http://spectrum.ieee.org/jan08/5815/2.
[136] The Economist, "*Xohm's law*", published 16 November 2007 (http://www.economist.com/science/displaystory.cfm?story_id=10159097)
[137] See for example http://news.bbc.co.uk/1/hi/technology/4785742.stm, http://www.telecomasia.net/article.php?id_article=5289 and http://www.motorola.com/mediacenter/news/detail.jsp?globalObjectId=9033_8962_23

Some recent developments that illustrate the breadth of industry efforts in relation to WiMAX

A3.19 In regulatory fora during late 2007, WiMAX gained international recognition as a mobile broadband standard. The International Telecommunications Union (ITU) admitted WiMAX technology into the IMT family of 3G mobile standards.[138] The IMT definition itself was also expanded itself during the World Radio Conference 2007 (WRC-07) in November 2007 to cover the next generation of mobile technologies. Furthermore, the WRC agreed to designate frequencies used for WiMAX internationally (i.e. 2.3-2.4 GHz and 3.4-3.6 GHz) as IMT radio frequency bands[139]. In Europe, members of the WiMAX Forum have also contributed actively to the preparation of CEPT's Report 19 and to the recommendations for least restrictive conditions for use of the 2.6 GHz band.

A3.20 Regarding equipment, there has been a number of recent announcements regarding the availability of network equipment (base stations) as well as end-user equipment (e.g. WiMAX-enabled phones, laptops and pocket-PCs), of which we list a few examples below.

3.20.1 Fujitsu announced the launch of three WiMAX base stations under its global BroadOne WiMAX brand for use in the 2.3 and 2.5 GHz bands[140] in February 2008, along with the launch of a radio frequency (RF) module for WiMAX[141]

3.20.2 Intel has been a leading proponent of WiMAX and has launched a range of WiMAX equipment, including a dual-mode WiMAX and WiFi module called "Echo Peak"[142], an integrated WiMAX chipset called "Baxter Peak" (which is expected to be included in the next version of Nokia's N800 Internet Tablet series which will be available on Sprint's Xohm network)[143] and a low-cost integrated WiMAX system on a chip (the Intel WiMAX Connection 2250).[144] At the Mobile World Congress 2008 in February, Intel gave with Nokia and Nokia Siemens Network a demonstration of continuous internet connection and handover between WiFi and WiMAX.[145] Intel also presented in March 2008 a new family of processors (Atom), of reduced size and power consumption, specifically designed for mobile internet devices.[146]

3.20.3 In addition to a number of WiMAX related announcements during 2007[147], at the start of 2008 Motorola announced the launch of a new 802.16e CPE

[138] See http://www.wimaxforum.org/news/pr/view?item_key=993a9f3e2bf2b5b6822364fd90738185f17f2de0
[139] See http://www.itu.int/newsroom/press_releases/2007/36.html and http://www.wimaxday.net/site/2007/11/16/wimax-a-key-beneficiary-as-wrc-expands-imt-spectrum-allocations/
[140] http://www.fujitsu.com/global/news/pr/archives/month/2008/20080206-01.html
[141] http://www.fujitsu.com/global/news/pr/archives/month/2008/20080207-01.html
[142] http://download.intel.com/network/connectivity/products/wireless/mobilize-your-internet.pdf
[143] http://download.intel.com/technology/wimax/deliver-wimax-faster.pdf
[144] http://download.intel.com/network/connectivity/products/wireless/IntelWiMAXConnection2250.pdf
[145] See http://www.informationweek.com/news/showArticle.jhtml?articleID=206402343 and http://blogs.intel.com/research/2008/02/wifi_wimax_handover.php#more
[146] http://vonmag.com/editorial/web-exclusives/intel-atom-family-slated-for-mobile-internet-devices
[147] See http://www.motorola.com/mediacenter/news/detail.jsp?globalObjectId=9037_8966_23&pageLocaleId=2026

and PC card[148], and also that it is to licence the IP for its WTM1000 mobile WiMAX chipset-based radio reference design to third parties, as well as using it in its range of WiMAX devices which will be used on Sprint-Nextel's Xohm network.[149]

3.20.4 In February 2007, Samsung announced that it would introduce the first cellular/mobile WiMAX phone, aimed principally at the South Korean market.[150] Samsung subsequently announced in November 2007 that it was preparing to launch a variety of products, including WiMAX-enabled laptops, phones and pocket-PCs.[151]

3.20.5 In January 2008, Posbro launched its mobile WiMAX gaming device, showing yet another application for WiMAX.[152] In February 2008, in anticipation of the Mobile World Congress taking place in Barcelona, there were a number of announcements by companies of new products and strategies. NextWave Wireless announced that it is collaborating with EB to introduce a commercial mobile WiMAX handset into the global market for wide-scale deployment[153].

3.20.6 In February 2008, ZTE announced a demonstration of a range of WiMAX products including USB modems and data cards.[154] The WiMAX Forum provided an update on its certification programme for equipment in the 2.6 GHz band, with 28 products under consideration, and noted that it expected certification for the first WiMAX products in the second quarter of 2008.[155] Mitsumi also showcased a mobile WiMAX SD-card.[156]

3.20.7 In March 2008, NextWave Wireless announced the launch of a solution to deliver rich and personalised multimedia services as part of a mobile WiMAX service.[157] Equipment manufacturers Huawei and Alcatel-Lucent have agreed to integrate Nextwave's technology in their WiMAX base stations.[158]

A3.21 These developments offer the prospect of a wide range of applications, including new and innovative uses of the internet and wireless connectivity in a broad sense.

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148 http://www.motorola.com/mediacenter/news/detail.jsp?globalObjectId=9250_9179_23&pageLocaleId=2026

149 http://www.motorola.com/mediacenter/news/detail.jsp?globalObjectId=9261_9190_23&pageLocaleId=2026

150 See http://www.samsung.com/global/business/telecommunication/newsView.do?b2b_bbs_msg_id=67 and http://www.dailywireless.org/2007/11/13/samsung-wimax-devices/

151 http://www.samsung.com/global/business/telecommunication/productInfo.do?ctgry_group=11&ctgry_type=16&b2b_prd_id=159

152 http://www.flyvo.com/WiMAX/about/news_view.jsp?searchKey=title&searchWord=&onPage=1&press_seq=116

153 http://www.foxbusiness.com/markets/industries/telecom/article/nextwave-wireless-eb-collaborate-develop-innovative-mobile-wimax-handset_467759_13.html

154 http://wwwen.zte.com.cn/main/News%20Events/Whats%20New/2008022860118.shtml

155 http://www.wimaxforum.org/news/pr/view?item_key=138e1080657b96738a279a92a2c3f8c0ce240d0a

156 http://www.sequans.com/news/press_releases/2008/2008_2_15_2.php

157 http://media.nextwave.com/phoenix.zhtml?c=215860&p=irol-newsArticle&ID=1116748&highlight=

158 http://www.telecoms.com/itmgcontent/tcoms/news/articles/20017514360.html

Intel is said to have developed plans to put WiMAX chips into a range of products, such as traffic lights, surveillance cameras, TV sets, medical equipment, digital cameras, portable music players and other mobile devices.[159] One example[160] of the range of uses that are possible is the pre-WiMAX network that Libera Networks is constructing for the municipal water company Communidad de Madrid, to monitor its water purifying stations in Spain. A further example is of telemedicine in Sweden, where healthcare personnel are able to visit patients who do not have fixed-line broadband and stay in touch with a doctor for consultations.[161] Other potential applications include video applications such as CCTV[162] or data services embedded in cars.[163]

Examples of planned investments relevant to WiMAX

A3.22 In November 2007, the Taiwan Ministry of Economic Affairs signed a memorandum of understanding with five manufactures and operators (Motorola, Alcatel-Lucent, Sprint-Nextel, Starent Networks and Nokia Siemens Networks (NSN)) to develop WiMAX products and services. NSN will initially invest US$14.2m in a WiMAX-testing facility. The Taiwanese government is expected to invest US$664m in WiMAX development over the next few years.[164]

A3.23 In January 2008, WiMAX Day estimated that the total capital to be invested in WiMAX networks and technology would be more than US$30 billion over the next year, with nearly half of this amount being consumed in the deployment of new networks. This figure does not include the investments from Sprint-Nextel (of US$5 billion over three years) nor the KDDI-Intel venture in Japan (which is expected to require US$1.3 billion[165]).

LTE

A3.24 Long Term Evolution (LTE) is a project within the Third Generation Partnership Project[166] (3GPP) to improve the Universal Mobile Telecommunications System (UMTS) mobile phone standard. This standardisation body, like the WiMAX Forum includes a range of organisations (including operators and manufacturers) and counts more than 320 individual members[167]. LTE is expected to be a major improvement to the UMTS standard. It has been perceived by some observers as a response to a perceived threat from WiMAX, and it has been suggested that the speed of its development has been stimulated by competition from WiMAX[168]. A number of industry commentators have reported on the competition between the two technologies[169] and some mobile operators (such as Deutsche Telekom[170]) are

[159] See Economist article "*Xohm's law*", published 16 November 2007 (http://www.economist.com/science/displaystory.cfm?story_id=10159097)
[160] http://www.wimaxday.net/site/2007/02/05/wimax-protects-water-supply-in-spain/
[161] http://www.wimaxday.net/site/2006/10/02/doctors-use-wimax-to-make-house-calls-in-sweden/
[162] http://www.btwholesale.com/pages/static/News_and_Briefings/Industry_News/18465135.html
[163] http://eetimes.eu/205600452
[164] http://www.informatm.com/itmgcontent/icoms/product/TG/459/20017476291.html
[165] http://www.unstrung.com/document.asp?doc_id=143285
[166] http://www.3gpp.org/
[167] See the full list at http://webapp.etsi.org/3gppmembership/Queryform.asp.
[168] http://www.arcchart.com/blueprint/show.asp?id=447&qtabs=99999
[169] See for example http://www.ft.com/cms/s/0/f007b334-d9d6-11dc-bd4d-0000779fd2ac.html?nclick_check=1, http://www.americasnetwork.com/americasnetwork/Daily+News/Mobile-industry-braces-for-WimaxLTE-wars/ArticleStandard/Article/detail/491382?contextCategoryId=1715,

also reported to have delayed their choice of next generation mobile technology in order to stimulate the development of LTE. LTE will be the next major enhancement to 3G family of technologies after HSPA and is expected to enable significant improvements in mobile network throughput. As LTE is an evolution of existing UMTS standards, its support comes mainly from within the mobile phone industry.

A3.25 LTE has the potential to be used in a number of bands, including the 2.6 GHz band but also other spectrum bands currently available and use for 2G and 3G mobile telephony (such as 900 MHz, 1800 MHz and 1.9/2.1 GHz). It is not clear which band(s) 3GPP will target first for the production of LTE equipment. Devices using LTE are expected to become commercially available during 2009 or 2010 at the earliest, with cross-vendor interoperability seen by some as the main stumbling block for the development of LTE.[171]

A3.26 LTE is at an earlier stage of development than WiMAX, with standards not yet finalised. Accordingly, there have been no major financial announcements regarding the technology, with ABI Research forecasting in February 2007 that mobile operators would invest almost US$18 billion in LTE equipment from 2007 to 2014 in LTE.[172] Nevertheless, a number of major operators and equipment manufacturers have publicly backed the technology, and investment in LTE, as the next evolution of existing UMTS networks, can be expected to be significant.

Some recent developments that illustrate the breadth of industry efforts in relation to LTE

A3.27 3GPP work on LTE began with a preliminary workshop in November 2004 and a completed specification is scheduled for 2008. A number of major operators such as Verizon and Vodafone are requesting that equipment will be available from vendors for initial trials by the end of 2008.[173] Early adopters, such as NTT DoCoMo in Japan (who is working with Nokia Siemens Networks and Panasonic), are pushing for deployment in 2009.

A3.28 A number of major operators, including Verizon Wireless,[174] AT&T,[175] China Mobile[176] and Vodafone,[177] have recently announced their backing for LTE. The Mobile World Congress in Barcelona in February 2008 saw a number of equipment manufacturers, including Ericsson, Nortel and Sandbridge, demonstrate LTE technology.

A3.29 In May 2007, the LTE/SAE (Systems Architecture Evolution) Trial Initiative was launched. This initiative initially included companies such as Alcatel-Lucent, Ericsson, Orange, Nokia, NSN, Nortel, T-Mobile and Vodafone and has recently expanded to include China Mobile, Huawei, LG Electronics, NTT DoCoMo, Samsung, Signalion, Telecom Italia and ZTE. A number of trials have been taking place under this initiative and initial results, which were described as a success,

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http://www.businesswire.com/portal/site/google/?ndmViewId=news_view&newsId=20080229005427&newsLang=en, or http://telephonyonline.com/wireless/news/ericsson-700- MHz-0312/.

[170] http://www.infoworld.com/article/08/03/03/Deutsche-Telekom-keeps-its-4G-options-open_1.html

[171] "Successful lab tests a milestone for LTE, but there is still a long way to go", article by Informa Telecoms and Media, dated 16 November 2007

[172] http://www.abiresearch.com/abiprdisplay.jsp?pressid=816

[173] http://www.engadget.com/2007/11/29/verizon-and-vodafone-to-launch-lte-trial-in-2008/

[174] http://search.ft.com/ftArticle?queryText=lte&aje=true&id=071129000549&ct=0

[175] http://www.ft.com/cms/s/0/1f0ad424-d4fd-11dc-9af1-0000779fd2ac.html

[176] http://www.ft.com/cms/s/0/116f0a30-d9d8-11dc-bd4d-0000779fd2ac.html?nclick_check=1

[177] ibid.

were announced in November 2007.[178] Further results were announced in February 2008 and were said to show that the prototype systems had achieved download speeds exceeding 100Mbps, with high performance systems reaching more than 300Mbps. These tests also demonstrated substantial improvements to network response times[179].

Awards and use of the 2.6 GHz band worldwide

A3.30 The award of the 2.6 GHz band is at different stages across the globe. It has been completed in a number of countries, and national regulators are making plans for the award of the band in the near future in a number of other countries. Furthermore, the 2.6 GHz band or similar bands such as the 2.3 GHz band (which allows for the provision of services which are comparable to those which could potentially be offered through the use of the 2.6 GHz spectrum) have already been awarded in a number of countries and services are either already available or networks are being deployed, providing further evidence of the interest in the band from service providers.

A3.31 This section first covers recently completed awards before briefly examining upcoming awards and concluding with a review of key markets where the 2.6 GHz and similar bands have already been awarded and are in use, or networks are being rolled out.

Recently completed awards of the 2.6 GHz band

A3.32 There are various countries where the award of the 2.6 GHz band has been recently completed. This section gives details of these awards, each of which has shown that there is significant interest among existing fixed and mobile operators in making use of the 2.6 GHz band, as well as interest in the band from new entrants such as Craig Wireless in Norway and New Zealand, and Global On and Tatung in Taiwan.

Japan

A3.33 The 2.5 GHz band was awarded by the Ministry of Internal Affairs and Communications in Japan in late 2007 to Wireless Broadband Planning K.K. (a consortium led by KDDI and Intel) and Willcom.[180] KDDI is planning to invest US$1.2 billion in rolling out its network and cover 93% of the population by 2012.[181]

A3.34 Only 80 MHz was available during the auction, with two nationwide licences of 30 MHz each being awarded with a 10 MHz guard band separating the two national licences and the remaining 10 MHz assigned to fixed uses in each region. In order to promote competition and the entrance of new service providers, the Japanese Ministry of Internal Affairs and Communications deemed Japanese mobile operators NTT DoCoMo, KDDI and SoftBank as ineligible to bid directly for licences in this award, and that operators of high-speed mobile services could only invest up to one-third of total capital in new companies seeking licenses.[182] As a result, all

[178] http://www.ericsson.com/ericsson/news/archive/2007/071108_super_fast_trial.shtml
[179] "LTE backers keep pedal to metal", article by Informa Telecoms and Media, dated 5 February 2008.
[180] http://www.wimaxday.net/site/2007/12/21/kddi-and-willcom-awarded-licenses/
[181] http://www.wimax-vision.com/newt/l/wimaxvision/magazine_view.html?section=7
[182] "Japan excludes mobile incumbents from WiMAX licensing", article by Informa Telecoms and Media, dated 23 May 2007

three of the incumbent mobile operators formed alliances to bid for spectrum in the 2.5 GHz auction.[183] The eventual winners are a consortium which includes KDDI as a member and a provider of a particular type of mobile services Personal Handy-phone System (PHS) based on a large number of small cells compared to more widespread mobile services as available in the UK and from other Japanese mobile operators.

A3.35 KDDI plans to launch WiMAX-based services in 2009 and has stated that it may also lease spectrum to other parties interested in offering WiMAX-based services. Willcom has also announced that it intends to launch services in 2009 using a next generation PHS based on orthogonal frequency-division multiplexing (OFDM).[184]

New Zealand

A3.36 The 2.3 and 2.5 GHz bands were awarded by auction in New Zealand in December 2007.[185] There were eight lots of spectrum, four of which were nationwide and suitable for WiMAX-type services, and four of which were nationwide and suitable for either WiMAX or cellular type services. The auction was completed after 30 rounds.

Table 11: Summary of 2.6 GHz auction results in New Zealand

Lot number	*Lower boundary*	*Upper boundary*	*Lot size (MHz)*	*Provisionally successful bidder*
1	2300 MHz	2335 MHz	35	Kordia Ltd
2	2335 MHz	2370 MHz	35	Woosh Wireless Ltd
3	2500 MHz	2520 MHz	20	Craig Wireless Systems Ltd
4	2520 MHz	2540 MHz	20	Telecom Leasing Ltd
5	2540 MHz	2575 MHz	35	Vodafone Mobile NZ Ltd
6	2620 MHz	2640 MHz	20	Craig Wireless Systems Ltd
7	2640 MHz	2660 MHz	20	Telecom Leasing Ltd
8	2660 MHz	2690 MHz	30	Blue Reach Ltd

Source: Ministry of Economic Development, New Zealand

A3.37 There are six provisionally successful bidders for the spectrum: Kordia; Woosh Wireless; Craig Wireless Systems; Telecom Leasing; Vodafone Mobile NZ; and Blue Reach. Telecom Leasing is a 100% owned subsidiary of the fixed line incumbent (Telecom New Zealand) has recently submitted an application to purchase the spectrum it provisionally won in the auction.[186]

[183] " Four bid for 2.5GHz in Japan", article by Informa Telecoms and Media, dated 20 October 2007
[184] "DoCoMo disbands WiMAX partnership", article by Informa Telecoms and Media, dated 21 January 2008
[185] http://www.rsm.govt.nz/cms/policy-and-planning/spectrum-auctions/2-3-2-5-ghz-auction
[186] http://www.telegeography.com/cu/article.php?article_id=21547&email=html

Norway

A3.38 The Norwegian Post and Telecommunications Authority (NPT) awarded the 2.6 GHz band in November 2007.[187] NPT awarded spectrum across six regions, with frequencies in the Oslo area being awarded for a very significantly higher price than for other more rural regions, reflecting higher potential mobile traffic density in this area.

A3.39 Figure 17 below shows the successful bidders for the 2.6 GHz spectrum in Norway by frequency band and region.

Figure 17: Summary of 2.6 GHz auction results in Norway

Frequency band (Lots)		Block		Region					
Lower (MHz)	Upper (MHz)			1	2	3	4	5	6
2010	2025	A	Unpaired	Inquam Broadband GmbH					
2500 / 2620	2505 / 2625	C1	Paired	Hafslund Telekom AS	NetCom AS				
2505 / 2625	2510 / 2630	C2	Paired	NetCom AS					
2510 / 2630	2515 / 2635	C3	Paired	NetCom AS					
2515 / 2635	2520 / 2640	C4	Paired	NetCom AS					
2520 / 2640	2525 / 2645	C5	Paired	Telenor ASA					
2525 / 2645	2530 / 2650	C6	Paired	Telenor ASA					
2530 / 2650	2535 / 2655	C7	Paired	Telenor ASA					
2535 / 2655	2540 / 2660	C8	Paired	Telenor ASA					
2540	2550	D1	Unpaired	Telenor ASA					
2550	2560	D2	Unpaired	Telenor ASA					
2560	2570	D3	Unpaired	Hafslund Telekom AS	Hafslund Telekom AS	Arctic Wireless AS	Hafslund Telekom AS	Arctic Wireless AS	Arctic Wireless AS
2570	2580	B1	Unpaired	Craig Wireless Systems Ltd.					
2580	2590	B2	Unpaired	Craig Wireless Systems Ltd.					
2590	2600	B3	Unpaired	Craig Wireless Systems Ltd.					
2600	2610	B4	Unpaired	Craig Wireless Systems Ltd.					
2610	2620	B5	Unpaired	Craig Wireless Systems Ltd.					
2660	2670	E1	Unpaired	Telenor ASA					
2670	2680	E2	Unpaired	Telenor ASA					
2680	2690	E3	Unpaired	Hafslund Telekom AS	Not assigned	Not assigned	NetCom AS	Not assigned	NetCom AS

Source: NPT

A3.40 The two incumbent Norwegian mobile operators, Netcom and Telenor, won the majority of the spectrum (eight blocks of 2x5 MHz in the 2500-2540 MHz band paired with 2620-2660 MHz). Telenor also won 40 MHz of unpaired spectrum (2660-2690 MHz). A new entrant, Canadian WiMAX operator Craig Wireless Systems, won 50 MHz of unpaired spectrum (2570-2620 MHz). Hafslund Telekom, Arctic Wireless and Inquam Broadband also won spectrum and appear to be new providers of wireless services in Norway. Three regional blocks in the top band (2680-2690 MHz) were unsold.

A3.41 NetCom and Telenor have stated that they intend to continue to deploy "Turbo 3G" technology such as WCDMA/HSPA and ultimately LTE in the paired spectrum they won[188].

A3.42 Furthermore, Telenor intends to use its unpaired spectrum in order to "position itself to offer access services on any of the emerging technologies, based on market demand, available equipment and prices"[189]. It included WiMAX among these emerging technologies, but also FDD-based services such as WCDMA/HSPA and LTE.

187 http://www.npt.no/portal/page/portal/PG_NPT_NO_NO/PAG_NPT_NO_HOME/PAG_RESSURSER_TEKST?p_d_i=-121&p_d_c=&p_d_v=50655

188 "Incumbent operators take bulk of Norwegian 2.6GHz spectrum", article by Informa Telecoms and Media, dated 27 November 2007

189 ibid

A3.43 Craig Wireless provides WiMAX-based services in Canada and Greece, and has announced plans to build similar operations in Norway.[190]

Taiwan

A3.44 The Taiwanese regulator, the National Communications Commission (NCC), awarded six WiMAX licences in August 2007 following thirteen applications for the licences.[191]

A3.45 First National Telecom; Global On; and a joint venture between Tecom and Vibo Telecom were awarded licences to provide WiMAX-based services to northern Taiwan, while Far EasTone Telecommunications, Tatung InfoComm and Vastar Cable TV were awarded licences for southern Taiwan.

A3.46 These licences are for the provision of WiMAX-based services. The winners have been given 18 months to build their WiMAX networks, with an extension of up to one year (subject to permission).

A3.47 Global On (which was renamed Global Mobile Corp in October 2007)[192] was formed in early 2007 as a venture capital fund focussed on WiMAX investments and is a new entrant to the Taiwanese telecoms sector, having not provided services prior to the award of these licences.

A3.48 Tatung, which is a manufacturer of computer and other electronic products, is another new entrant into the Taiwanese telecoms market.

Upcoming awards of the 2.6 GHz band

A3.49 In addition to the completed awards discussed in the previous section, there are a number of proposed awards of the 2.6 GHz band throughout the world which provide further evidence of interest in the use of the band. Table 12 below summarises the current proposals for a number of countries.

Table 12: Summary of upcoming awards of the 2.6 GHz band

Country	*Indicative timetable for award and comments*
Austria	Planned for 2008[193]
Germany	Planned for early 2008[194]
Hong Kong	The Hong Kong Office of the Telecommunications Authority (OFTA) has announced that the auction of the 2.6 GHz band will move forward to Q4 2008 and be combined with an auction of the 2.3 GHz band[195]

[190] http://www.newswire.ca/en/releases/archive/November2007/14/c8300.html
[191] http://www.wimaxday.net/site/2007/07/26/six-licenses-granted-in-taiwan/
[192] http://www.wimaxday.net/site/2007/10/17/global-mobile-launches-wimax-content-alliance-in-taiwan/
[193] http://www.wimaxday.net/site/2007/09/18/austria-sets-auction-of-25-ghz-spectrum-for-2008/
[194] http://www.rfdesignline.com/news/197003696
[195] http://www.wimaxday.net/site/2007/12/07/hong-kong-accelerates-auction-of-25-ghz-spectrum-for-wimax/

India	The Indian Department of Telecommunications has asked the department of space and telecom operators to vacate some spectrum in the 2.5 GHz band in preparation for an award of spectrum in the band for broadband wireless access services.[196]
Moldova	The Moldovan Ministry of Information Development has announced that it plans to auction spectrum in the 2.5 GHz band, with auctions potentially taking place as soon as August 2008.[197]
The Netherlands	The Dutch Ministry of Economic Affairs plans to publish the auction rules in March 2008, with a consultation planned to follow in Q2. It plans to hold information sessions about the auction in Q3, with the auction itself planned to start in Q4 2008[198].
Sweden	Scheduled to take place in April 2008[199]
Thailand	The National Telecommunications Commission (NTC) was due to award licences in the 2.5 GHz and 3.5 GHz bands by the end of 2007,[200] although there has been no further indication of timing from the NTC.
Ukraine	The National Commission of Communications (NCRC) has indicated that it will licence the 2.5 GHz band for use by WiMAX in the near future.[201]

A3.50 Spain and Italy are also likely to hold awards of the band in 2008, and France in 2010.[202]

Key markets where services in the 2.6 GHz band or similar bands are available or being developed

A3.51 In addition to the evidence presented earlier regarding recently completed and upcoming awards of the 2.6 GHz band, there are a number of countries (such as South Korea and the US) where the 2.6 GHz and similar bands have already been awarded and services are either launched or networks being rolled out. These markets provide evidence of innovation in wireless services as well as further evidence of continuing interest in the use of the band by service providers.

A3.52 Other countries where those spectrum bands are in use for mobile broadband services include Bulgaria,[203] Russia[204] and Singapore, where port operators provide data rich services to vessels in coastal waters or at port.[205]

[196] http://www.telegraphindia.com/1080116/jsp/business/story_8786868.jsp; and http://www.thehindubusinessline.com/2008/01/14/stories/2008011451450200.htm
[197] http://www.wimaxday.net/site/2008/02/13/25-ghz-auction-in-moldova/
[198] http://www.minez.nl/content.jsp?objectid=150015&rid=153445
[199] http://www.pts.se/Sidor/sida.asp?Sectionid=3294&Itemid=&Languageid=EN
[200] See http://www.wimaxday.net/site/2007/03/13/wimax-licenses-in-thailand-at-year-end/
[201] See http://www.wimaxday.net/site/2007/06/21/ukraine-may-soon-auction-25-ghz/
[202] See for example Telecom Services, Global Equity Research Europe, Lehman Brothers, 15 January 2008.
[203] http://money.cnn.com/news/newsfeeds/articles/marketwire/0360031.htm

South Korea

A3.53 Mobile broadband services have been available in South Korea from two operators, Korea Telecom (KT) and SK Telecom (SKT), since June 2006. Services are offered in the 2.3 GHz band under the WiBro (Wireless Broadband) name. WiBro is based on the same IEEE 802.16e standard as mobile WiMAX and is a member of the WiMAX family.[206]

A3.54 WiBro was launched in South Korea in June 2006 as a commercial service by KT and SKT. Initial take-up was low with only around 1300 subscribers by November 2006 with analysts commenting that limited network coverage (SKT had been focussing on its HSDPA network during 2006), the lack of handheld WiBro devices and the high cost of access were restricting growth.[207]

A3.55 In addition, WiBro was launched in a market where mobile broadband services were already available. S-DMB and T-DMB (Satellite Digital Multimedia Broadcasting and Terrestrial Digital Multimedia Broadcasting) were launched in May[208] and December[209] of 2005 respectively and provide multimedia services to mobile devices. S-DMB covers the whole of South Korea, while T-DMB is available in selected areas.

A3.56 KT in particular continues to back the technology and has recently announced that it will invest KRW120 billion (£65 million) in expanding the coverage of WiBro to the whole of the metropolitan area of Seoul (which contains half of Korea's population) in addition to existing coverage of Seoul, Bundang and hotspots in Busan, Daegu, Daejeon, Gwangju and Ulsan.[210] The company further expects subscriber numbers to grow from 100,000 as of the end of December 2007 to 400,000 by the end of 2008.[211]

US

A3.57 Sprint-Nextel holds a near national licence in the US in the 2.6 GHz band and is the holds the largest amount of 2.6 GHz spectrum in the country. In August 2006, the company announced that it would invest US$2.5–3 billion before the end of 2008 rolling out a mobile WiMAX based network to cover 80–85% of households[212].

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[204] http://www.telecoms.com/itmgcontent/tcoms/require-reg.html?prevurl=/tcoms/news/articles/20017487717.html&artid=20017487717&producttype=news

[205] http://www.wimaxday.net/site/2008/03/06/singapore-offers-mobile-wimax-up-to-10-miles-off-shore/ or http://www.tmcnet.com/usubmit/2008/03/10/3316590.htm

[206] See http://www.wimaxforum.org/news/WiBro_and_Mobile_WiMAX_Backgrounder.pdf

[207] "WiBro needs devices, content and coverage to succeed", article by Informa Telecoms and Media, dated 18 July 2006

[208] http://www.asiamedia.ucla.edu/article.asp?parentid=23866

[209] http://www.asiamedia.ucla.edu/article.asp?parentid=34172

[210] http://www.koreatimes.co.kr/www/news/nation/2008/02/133_18482.html

[211] http://event.kt.com/kthome/download.jsp?num=159&filename=KT_Announces_Management_Plan_for_2008_eng.pdf

[212] In September 2006, Sprint-Nextel launched their FanView service which allows NASCAR fans to rent a PDA style device at the race track which receives race data, including video and audio feeds, over the 2.5 GHz band using DVB-H (http://www2.sprint.com/mr/news_dtl.do?id=10220). The device was named as one of TIME magazine's best 100 inventions of 2006.

A3.58 In July 2007, Sprint-Nextel announced that it would partner with Clearwire to deploy a nationwide network[213] with the name of the service, Xohm, announced in August 2007 and commercial service launch expected in the first half of 2008.

A3.59 Since that time, a number of analysts have questioned the future of Sprint-Nextel's Xohm service, for example when Sprint-Nextel's CEO Gary Forsee resigned and the company cancelled the partnership with Clearwire. However, Sprint-Nextel has now announced the upcoming soft launch of Xohm in a number of cities including Chicago, Baltimore and Washington D.C.[214].

A3.60 On the equipment side, Sprint-Nextel announced a number of key strategic partnerships in January 2007 with companies such as Nokia, Motorola, Samsung, LG and Intel.[215] More recently, the company announced a number of further service partnerships (including CRM, customer care services, online security and hosted storage for customers) and WiMAX network access devices from manufacturers such as ASUSTek, Zyxel Inc. and OQO.[216] It has also been announced that Google will supply portal services for the network.

A3.61 When considering Sprint's plans to invest in its Xohm service, it seems important to take account of the specific circumstances of the operator, given the current performance of Sprint's other existing core business and recent losses in subscriber numbers. However, its CEO has recently indicated that they remain committed to their WiMAX plans under the Xohm brand.[217]

A3.62 Clearwire, who also has rights to use significant parts of the 2.6 GHz band in the US, has already started providing broadband services and has plans to develop its coverage in 2008 and introduce mobile WiMAX technology in the second half of 2008. As set out in the summary of their results for the fourth quarter of 2007 and for the full year[218], they have seen substantial growth in subscriber numbers and service revenue, while more than doubling their network footprint. They also identify the deployment of mobile WiMAX technology as one the main themes for 2008.

General trends in demand for mobile broadband services

A3.63 In this section, we provide a summary of industry analysis regarding use of and demand for mobile broadband services. We provide a small sample of relevant results and forecasts which have become available since publication of the Discussion Document and that illustrate views on demand for mobile broadband services.

Take-up of mobile broadband services seems to be accelerating in the UK and other mature markets

A3.64 Informa[219] reports an annual increase in average revenue per user of approximately 30% between Q3 2006 and Q3 2007, for data services excluding SMS for both O2 and Vodafone. This takes non-SMS data revenues as a share of total data revenues from 13% in Q3 2006 to 15% in Q3 2007 for O2 and from 28% in Q3 2006

[213] http://www.xohm.com/news-071907.html
[214] http://www.xohm.com/news-010808.html
[215] See http://www2.sprint.com/mr/news_dtl.do?id=15000
[216] http://www.xohm.com/news-010808.html
[217] See for example http://rcrnews.com/apps/pbcs.dll/article?AID=/20080301/SUB/411173260/1002 or
[218] http://newsroom.clearwire.com/phoenix.zhtml?c=214419&p=irol-newsArticle&ID=1114995&highlight=
[219] See "Global non-SMS mobile data revenues by operator, 3Q07", Informa Telecoms & Media

to 29% in Q3 2007 for Vodafone. (The data set does not include information on other UK MNOs.) For other western European operators covered, increases in non-SMS data revenues over the same period vary from approximately 20% to 95%.

A3.65 Similarly, in mature markets where non-SMS data revenues were still relatively low in Q3 2006, such as Canada and the USA, Informa reported increases in average revenue per user of approximately 55% to 230% for the operators covered.

A3.66 In November 2007, Merrill Lynch also highlighted these recent trends of significant increases in data usage, by reporting an average annual growth of 28% for wireless data services (including SMS) across a range of geographical markets.[220] They also note that shipments of handsets suitable for mobile broadband services have increased substantially across Europe, Japan and North America, at annual rates in excess of 30% from 2004 to 2006, and they expect that trend to continue at an annual rate of the order of 30% in 2008-2010. UBS, in January 2008[221], also reported significant growth in non-SMS mobile broadband revenues for European operators for the period 2005-2007 and expected this trend to continue through to 2010.

A3.67 We also note recent some developments in relation to the take-up and use of certain devices, which further indicates that the increase in mobile broadband usage identified in forecasts is starting to take place. Experience from recent mobile devices which offer advanced functionality, such as the iPhone, seem to confirm that view, with significant increases in the use of mobile broadband services.[222] Analysts have also commented on the take-up in wireless modems with the availability of plug-and-play USB dongles of small form factor.[223]

A3.68 While it expresses doubts about the scope for internet use on mobile devices to reach the mass market in the current environment, a note from Enders Analysis of February 2008[224] identifies the potential for large scale growth of mobile broadband use through specific applications. Enders also identify the importance of pricing plan, quality of service and device properties in supporting such growth in mobile broadband use.

Forecasts for future mobile broadband demand and usage suggest strong potential for growth

A3.69 Merrill Lynch[220] set out their anticipation that current and future conditions (in terms of networks, services and devices) should result in sustained and further growth in mobile data usage generally in a range of markets including western Europe. This general view is illustrated in various forecasts of average revenue per user (ARPU), subscriber numbers and traffic volumes, of which we summarise a small selection below.

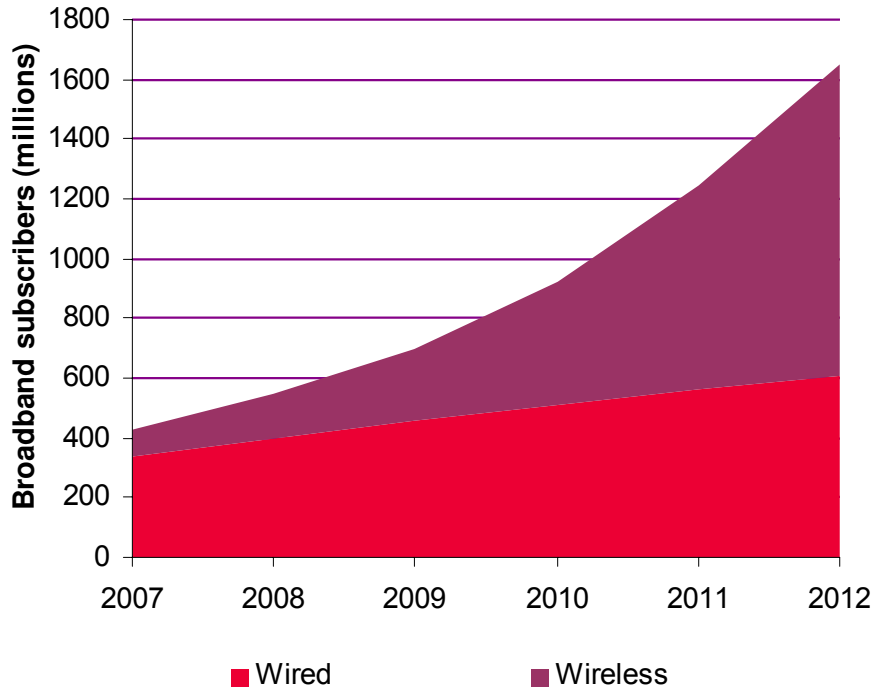
[220] "Wireless data growth: How far, how fast… and who wins?", Equity | Global | Telecom Services-Wireless/Cellular, Merrill Lynch, 28 November 2007.
[221] "Calling fundamentals – the UBS Wireless Quarterly", Global Equity Research, Europe including UK, Telecommunications, Sector Comment, UBS, 9 January 2008.
[222] See for example "iPhone boost for Google's mobile search", Financial Times, 14 February 2008 (http://www.ft.com/cms/s/0/656db956-daa0-11dc-9bb9-0000779fd2ac.html) or http://www.unstrung.com/document.asp?doc_id=147917.
[223] See for example Vodafone Group, Wireless broadband users shown the stick, Equities research | Company, Mobile | United Kingdom, Dresdner Kleinwort, 16 January 2008.
[224] Enders Analysis, The internet….on your mobile? [2008-21e], February 2008

A3.70 Considering the potential for data ARPU growth, Lehman, in January 2008[225], forecast a growth in non-SMS mobile data ARPU of approximately 70% to 130% for the period 2007-2010 in Europe, equivalent to approximately 20% compounded annual growth rate.

A3.71 As an example of operator-specific forecasts, Merrill Lynch[220] reports an estimate from Telefonica that O2 UK will see a 25% compounded annual growth rate in non-SMS data ARPU over five years.

A3.72 Turning to the number of subscribers of mobile broadband services worldwide, forecasts by Informa[226] for the period 2007-2012 show significant increases in worldwide wireless broadband subscribers of the order of 63% compounded annual growth rate, far in excess of the increase for fixed broadband. These forecasts are illustrated in Figure 18.

Figure 18: Broadband subscribers worldwide 2007-2012 (Informa)

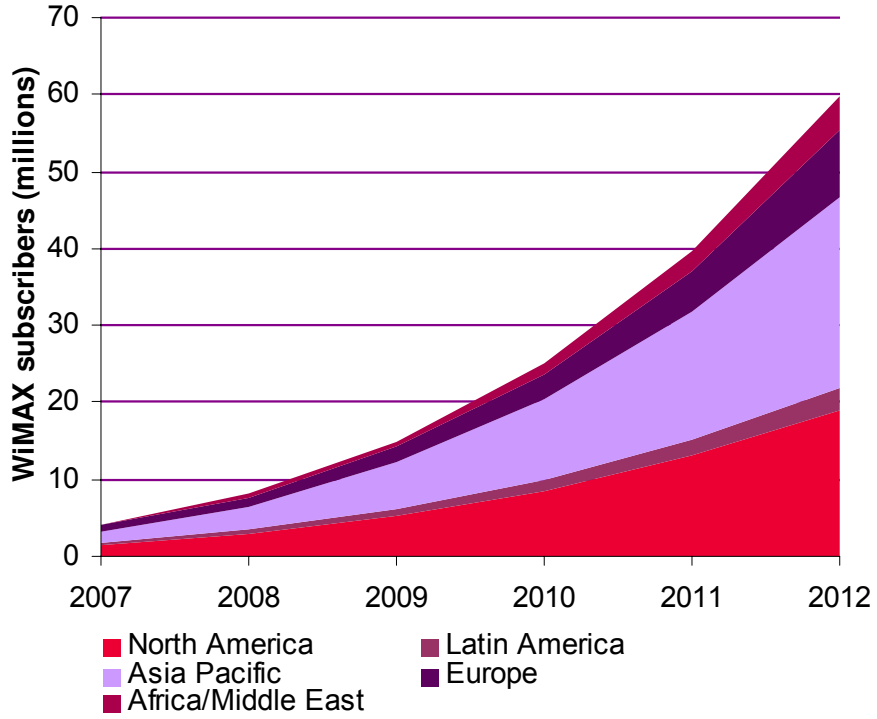


Note: Wireless includes WiMAX, pre-WiMAX, EV-DO, HSPA and evolutions, but excludes WCDMA and Wi-Fi.
Source: Informa Telecoms & Media.

A3.73 In respect of WiMAX subscribers, Informa forecast[227] a compounded annual growth rate of 63% in Europe, 66% in North America and 76% in Asia Pacific for the period 2007-2012, as shown in Figure 19.

[225] Telecom Services, Global Equity Research, Europe, Lehman Brothers, 15 January 2008.
[226] Global total broadband subscribers, by wired and wireless, 2007-12, Informa Telecoms & Media
[227] Global WiMAX subscribers, by region, 2007-12, Informa Telecoms & Media.

Figure 19: WiMAX subscribers in different regions 2007-2012 (Informa)



Note: Data includes subscribers using 802.16e-2005, 802.16-2004 or pre-WiMAX.
Source: Informa Telecoms & Media.

A3.74 Informa figures[228] for the number of subscribers for 3GPP technologies (HSDPA, HSUPA, HSPA+, LTE and TD-CDMA but excluding WCDMA) shows a compounded annual growth rate of 117% for the period 2007-2012 in Europe.

A3.75 Other forecasts have covered the potential growth in data traffic. The UMTS Forum responded to the July 2007 consultation by French regulator ARCEP regarding the digital dividend to inform regulatory decisions regarding the use of UF spectrum for mobile and/or other uses.[229] The UMTS Forum provided an estimate that the total daily traffic for mobile services in a representative western European country would grow by a factor of 23 between 2012 and 2020. This is equivalent to a compounded annual growth in traffic of 48% over that period. The forecast also included an increase in the proportion of data services (excluding voice and multimedia messaging services) from 56% in 2012 to 63% of total traffic in 2020.

A3.76 Spectrum-Value Partners prepared a report[230] for Ericsson, Nokia, Orange, Telefónica and Vodafone for the purpose of informing decisions at WRC-07 regarding future allocation of spectrum for mobile use. The report also sets out significant increases in traffic, measured in average data usage per subscriber (based on consideration of a selection of countries). Spectrum-Value Partners consider three scenarios for future growth (conservative, medium, optimistic) and provide estimates for the period 2007-2011 which also correspond to compounded

[228] Europe mobile broadband subscribers, by technology family, 2007-12, Informa Telecoms & Media
[229] http://www.art-telecom.fr/uploads/tx_gspublication/contrib-divnum-UMTS-Forum.pdf
[230] Assessing the impact of an early decision on digital dividend spectrum allocation, Spectrum Strategy – Value Partners, 16 October 2007. Available at http://www.spectrumstrategy.com/Pages/GB/perspectives/An-early-allocation-of-UHF-spectrum.pdf.

annual growth rates in excess of 50% (conservative), in excess of 80% (medium) and in excess of 100% (optimistic).

A3.77 In a white paper published in September 2007[231] ahead of WRC-07, the WiMAX Forum made forecasts available which highlight significant potential growth in mobile data traffic in Europe:

a) Informa estimated a compounded annual growth rate of 70% (conservative scenario) to 74% (aggressive scenario) for the period 2007-2015; and

b) Telecompetition estimated a compounded annual growth rate of 59% for the period 2010-2020.

A3.78 Forecasts for end-user demand are inherently uncertain and should be interpreted with care as they are based on a set of forecasted assumptions including, *inter alia*, pricing, availability, quality of service and end-user interest. However, while specific figures are subject to significant uncertainty, the representative examples presented above suggest that demand for mobile broadband services is likely to increase substantially in the short and medium term.

[231] "A review of spectrum requirements for WiMAX equipment to support wireless personal broadband services", WiMAX Forum, September 2007. Available at http://www.wimaxforum.org/technology/downloads/Spectrum_Requirements_for_Mobile_WiMAX_Sept2007.pdf.

Annex 4

Indicative quantification of competition and innovation benefits

A4.1 This Annex sets out our indicative quantification of the competition and innovation benefits described above which might flow if the 2.6 GHz band were awarded as soon as practicable and according to our proposals for technology neutrality.

A4.2 We have developed what we consider reasonable approaches to modelling the highly complex competitive and dynamic interactions that could take place in the provision of mobile services[232].

A4.3 To model the potential impact of greater competition we have implemented a *Cournot oligopoly model* to provide an illustrative quantification of the welfare implications of changing the number of players in a market. At a high level the model compares the changes in producer and consumer surplus from increasing the number of players from the current five in the market. The period modelled is 20 years from 2007/08.

A4.4 To model potential innovation benefits, we have hypothesised that an outcome of an increase in dynamic efficiency from awarding the 2.6 GHz band may be an acceleration in innovation **by one year.** For example, in more competitive markets there may be a greater incentive to improve the quality of the service provided over time. The results should be seen as an indicative estimate of the potential welfare gain However, it is worth noting that modelling the flow of benefits from innovation is an inherently difficult task that is subject to much uncertainty.

Key results

A4.5 Our model estimates the **welfare benefit from greater competition in the mobile market** – the sum of changes in producer and consumer surplus – to range from **a total welfare gain of £800 million** in the case of one additional player (i.e. going from five to six players) to **£1.7 billion** in the case of three[233] (going from five to eight players). This is the net welfare effect of increases to consumers and losses to incumbents from reductions in prices. For comparison, a reduction in the number of competitors from five to four (as estimated in the Mobile Liberalisation Consultation) would lead to a fall in total welfare of £1.1 billion.

A4.6 We used the *Cournot oligopoly* model (which makes the simplification that firms compete on the basis of quantity) to estimate changes in price[234] due to an increase in the number of players in the market compared to a forecast of the prices that would obtain if the number of players in the mobile market remained at the current

[232] We have used the same models that were used in our Consultation: Application of spectrum liberalisation and trading to the mobile sector published September 2007
[233] 20 year NPV, 2007/8 prices, assuming entry in 2008/9, elasticity of demand of –1 and a real social discount rate of 3.5%
[234] The price calculated was the ARPU, average revenue per user (or subscriber).

level of five[235] (as a modelling simplification, the market shares of the five operators were assumed to be equal). This model also allowed us to impute the implied marginal cost consistent with the given prices, the number of subscribers[236] and an elasticity of demand (in our central case, we specified this as –1). Hence we were able to estimate the changes in consumer and producer surplus from entry into the market.

A4.7 We note that, in response to the Mobile Liberalisation Consultation, Vodafone questioned the use of the Cournot model to estimate welfare benefits associated with changes in market structure, and whether changes in market structure would lead to changes in competition[237]. We disagree that the Cournot model is unsuitable for our modelling of potential welfare benefits. We note the limitations of the Cournot model, however, we consider that it does capture the fundamental impacts of entry on competition. We also consider that it is appropriate in that we are only seeking to provide an indication of the potential competition benefits of awarding the spectrum as soon as practicable. The Cournot model also has the benefit of being analytically tractable and we do not consider that the more complex oligopoly models (which might fit the mobile market) would produce a significantly different or more accurate result.

A4.8 We also recognise that there are a number of different models of competition that could be applied to an oligopoly market structure. However as noted in the main section of this Statement, we consider that there is solid theoretical and regulatory foundation for the view that changes in market structure will affect competition.

A4.9 While the dynamic interactions of the mobile market may be complex, the Cournot model provides a useful indication of the potential impact on competition of changes in the mobile market structure. We note that the Cournot model has been put forward as an approximation of a more complicated dynamic process in describing competition in the mobile market. Kreps and Scheinkman[238] show how a two-stage game in which firms set capacity first and then set prices produces results that are similar to the outcome of a Cournot model. Other models such as the Bertrand model with differentiated products (where firms compete on prices) also predict that competition will increase with entry.

A4.10 The only oligopoly model which does not produce this result, the Bertrand model with homogenous products does not appear to fit the facts of the industry. Services do not appear to be homogenous since we can observe significant differentiation in mobile services, e.g. different tariff packages, service and handset functionalities and coverage (for mobile broadband services). Moreover, the model assumes no fixed and sunk costs and no capacity constraints. Furthermore, empirical evidence from the mobile market also finds a positive link between the number of players and competition in mobile markets[239]. Therefore we conclude that it is reasonable to use

[235] A forecast of total revenue is based on UK mobile market retail revenues, sourced from the preliminary estimates for the Ofcom Communications Market 2007 publication

[236] We took the number of subscribers in the UK in 2006/7 as a starting point and related its growth to forecast population growth, thus assuming that the market was close to saturation

[237] We note that further comments were made on the specifics of the competition and oligopoly models presented in the Mobile Liberalisation Consultation and we are currently considering them in our ongoing work on this topic.

[238] D. Kreps, J. Scheinkman, Quantity Pre-Commitment and Bertrand Competition Yield Cournot Outcomes, Bell Journal of Economics, 1983

[239] H. Koski and T. Kretschmer, “Entry, standards and competition: firm strategies and the diffusion of mobile telephony” Review of Industrial organisation 2004

the Cournot model to produce indicative estimates of the impact of our proposals on competition.

A4.11 Our model estimates the **increase in total welfare from greater innovation** to range from **£200 million** to **£1.4 billion**[240]. This depends chiefly on the model's assumptions as to the amount by which innovation in the mobile market increases producer and consumer surplus and the length of time it takes innovation to "catch up" where there is a delay.

A4.12 We model the flow of economic benefits over twenty years from 2007/08, with and without a one-year acceleration[241] in the introduction of new innovations. For our base case, we model a 20-year period from 2007/8, with 3G services having been launched four years before the start of our modelling period (in 2003/04) and 'further advanced services' launched in 2014/2015. In the accelerated case, further advanced services are launched one year earlier in 2013/2014. The use of the terms '3G' and 'further advanced services' here is illustrative; our model was designed to show the general impact of a delay in the launch of these *types* of services, rather than delays to specific services. We consider that our assumption of a one-year acceleration in innovation is conservative, though it is difficult to put a precise measure on potential size of the delay[242].

A4.13 However we assume that the difference between take-up in the accelerated scenario and in the base case disappears over time. Thus the penetration of further advanced services in the base scenario 'catches-up' with the accelerated case penetration in 3, 5 or 7 years following the launch of further advanced services. This makes the implicit and conservative assumption that the level of competition does not affect the take-up of mobile services as a whole in the long run.

A4.14 We also assume that the total economic value of further advanced services is some percentage over and above the economic value generated by 3G services[243]. The size of this welfare uplift per user is highly uncertain, therefore we allow a wide range of values. Our lowest value of 10% assumes that each successive innovation produces 10% more economic value (the sum of consumer and producer surplus), whilst the highest value used is 50%.

Summary

A4.15 The overall modelled welfare benefits of awarding the 2.6 GHz band as soon as practical therefore fall in the range **£1 billion** to **£3.1 billion**. The breadth of this range indicates the inherent uncertainty in quantifying these effects. However, we consider that its analysis does illustrate that the welfare benefits of awarding the 2.6 GHz band are potentially very substantial.

[240] 20 year NPV, 2007/8 prices, assuming entry in 2008/9, further advanced services launched in 2014/15 and a real social discount rate of 3.5%

[241] We consider the choice of a one year difference conservative. It is based on an observed correlation in Europe between earlier 3G network roll-out and more 3G players.

[242] We have analysed how differences in market structure (e.g. in the UK and Germany as opposed to France) affected the launch of 3G changes and this supports our contention that greater competition could accelerate innovation.

[243] Similar assumptions on the uplift in economic value of 3G over 2G services, are standard in business case modelling for 3G.

A delay to the award of the 2.6 GHz band could reduce competition and innovation benefits

A4.16 If the award were delayed this would lead to a reduction in the potential competition and innovation benefits of awarding the spectrum. We discuss each in turn in the following sections.

Competition benefits

A4.17 Our quantitative assessment of the impact of a delay on the potential competition benefits that could arise from awarding the spectrum is relatively straightforward. However, if a delay to the award means that the window of opportunity for entry into the mobile market closes, then the reductions in competition benefits could be much greater than our estimate presented here.

A4.18 For every year of delay, the static competition benefits (i.e. the total welfare from reductions in price due to an increase in competitive intensity) which would have been gained in that year will be lost. Therefore, according to our analysis of competition benefits discussed above, for each year of delay to the award competition benefits might fall by between roughly **£ 70 million** to **£150 million**[244] - depending on whether the number of competitors increased from five to six or five to eight. If delay to the award meant the window of opportunity for entry to the mobile market had closed, the potential loss in benefits could be significantly greater up to the £800 million - £1.7 billion as reported in paragraph A4.5.

Innovation benefits

A4.19 We do not consider that a reliable estimate for the impact of a delay on innovation benefits can be produced. Given that we have modelled the impact of awarding the spectrum as soon as possible as bringing forward the launch of further advanced services by one year, the impact of a delay is very uncertain. It is possible that the launch of further advanced services might still be accelerated, but by less than one year, but it is also possible that they might be not be brought forward at all.

A4.20 We also note that our model of innovation benefits is only able partially to quantify the potential impact of awarding the 2.6 GHz band on innovation and more widely, dynamic efficiency. For example, the potential deployment of WiMAX technologies could generate longer term dynamic efficiency benefits by spurring the development of other competing technologies, and that this appeared to be happening with LTE and HSPA[245]. Furthermore, if there is a narrow window of opportunity for entry into the market, a delay to the award may stymie the prospects for entry and the whole of the innovation benefit could be lost.

[244] In fact the cost of a delay will be higher in the earlier years than in later years because the competition benefits are discounted in order to calculate net present values.
[245] Moreover, there is a risk that consumers lose interest in mobile applications and turn to fixed equivalents offering less functionality and utility (tentative argument) and there is a risk that certain wireless applications do not get developed as the supporting technology isn't there.

Annex 5

Confidential Annex regarding confidential issues raised by a respondent on the award of 2.6 GHz and 2010 MHz

A5.1 ✂

A5.2 ✂

A5.3 ✂

A5.4 ✂

✂

A5.5 ✂

A5.6 ✂

A5.7 ✂

A5.8 ✂

A5.9 ✂

A5.10 ✂

A5.11 ✂

Annex 6

Adjacencies with Programme Making and Special Events use

A6.1 This Annex presents a revised assessment of the potential for interference into PMSE receivers from candidate FDD and TDD systems operating in the 2.6 GHz and 2010 MHz award bands.

A6.2 The results have been updated from that presented within the December 2006 Consultation and subsequent Discussion Document to include the reduced out-of-band emission requirements set for base stations operating in the 2.6 GHz and 2010 MHz bands.

Minimum Coupling Loss calculation

A6.3 The assessment of the potential for interference is presented within this Annex is based on the methodology contained within the Engineering Study Phase 2 Report by Mason Communications Ltd that accompanied the December 2006 Consultation[246]. This adopted the minimum coupling loss (MCL) calculation described within the European Radiocommunications Committee (ERC) Report 101[247].

A6.4 Here an isolation loss between an interfering and victim system is estimated based on an assumed receiver protection criterion. This loss is then converted into an indicative separation distance between the systems.

A6.5 In the calculation of the isolation loss, use is made of the Adjacent Channel Interference Ratio (ACIR) parameter as specified within Report ITU-R M.2030[248]. This parameter is a measure of the degree of isolation between adjacent systems and represents the protection ratio that is afforded to the receiver. It is defined as a ratio of the total power transmitted from a source to the total interference power affecting a receiver, resulting from both transmitter and receiver impairments.

A6.6 The ACIR is derived by the addition of two other radio system parameters: an adjacent channel receiver selectivity (ASC) parameter and an adjacent channel leakage ratio (ACLR) parameter. The ACS is a function of the receiver characteristics and corresponds to the noise power that is received from an adjacent channel transmission due to imperfect receiver filtering. The ACLR is a function of the adjacent channel transmitter characteristics, and corresponds to the out-of-band emissions produced by the adjacent channel transmission that are received co-channel. These ACLR and ACS parameters are typically specified

[246] http://www.ofcom.org.uk/consult/condocs/2ghzawards/masonresearch.pdf
[247] A Comparison of the minimum Coupling Loss Method, Enhanced Minimum Coupling Loss Method, and the Monte-Carlo Simulation", ERC Report 101, May 1999 (http://www.erodocdb.dk/Docs/doc98/official/pdf/REP101.PDF)
[248] Coexistence between IMT-2000 time division duplex and frequency division duplex terrestrial radio interface technologies around 2 600 MHz operating in adjacent bands and in the same geographical area', REPORT ITU-R M.2030

within equipment standards or can be derived from performance compliance specifications.

A6.7 The relationship between ACIR, ACLR and ACS is given by Equation 1.

Equation 1: Adjacent Channel Interference Ratio

$$ACIR = \frac{1}{\frac{1}{ACLR} + \frac{1}{ACS}}.$$

A6.8 Once the ACIR is calculated, the MCL of a communications link is calculated by Equation 2.

Equation 2: Isolation:

$$\text{Isolation} = P_{INT} + dB_{BW} + G_{VICT} + G_{INT} - (S_{VICT} - C/I_{VICT}) - ACIR$$

Where all parameters are in dB and:

- P_{INT} is the maximum transmit power of the interferer.
- dB_{BW} is the bandwidth conversion factor between interferer and victim.
- G_{VICT} is the gain of the victim antenna (inc. cable loss).
- G_{INT} is the gain of the interferer antenna (inc. cable loss).
- S_{VICT} is the sensitivity of the victim.
- C/I_{VICT} is the protection ratio of the victim.
- ACIR is total interference power affecting a victim receiver relative to the interferer's carrier power.

Note the parameter (S_{VICT} - C/I_{VICT}) equates to the assumed permissible interference level a receiver.

A6.9 This isolation loss required between two systems may be achieved through a physical separation, a frequency separation, the incorporation of mitigation factors such as filtering, or most likely, a combination of these techniques.

Revised Analysis

A6.10 The PMSE and mobile system parameters assumed in the analysis are listed in Table 13 and Table 14 below. In general the system parameters are identical to those assumed within the original Ofcom analysis presented within Annex 8 of the Discussion Document, and in the Engineering Study Phase 2 Report by Mason Communications Ltd that accompanied the December 2006 Consultation, except for the ACLR values for base-station transmissions that have been revised to account for the reduction in out of band emission requirements that will be set by Ofcom to mitigate the impact of use of the 2.6 GHz and 2010 MHz bands on adjacent PMSE services.

A6.11 Results are presented for use with and without a channel filter at the PMSE receiver.

Table 13: PMSE receiver parameters

Receiver Parameters	Antenna Rx Gain (dBi)	Inteference Level (dBm)	Adjacent Channel Selectivity @ 7.5 MHz - ACS (dB)	Adjacent Channel Selectivity with use of channel filter @ 12.5 MHz (dB).
Radio Camera 1W	0.0	-107	46	86
Portable/Mobile links	8.0	-107	46	86
Airborne links	8.0	-107	46	86
Temporary point to point	20.0	-107	46	86

Table 14: UMTS/WiMAX transmitter parameters

Transmitter Parameters	Tx Power (dBm)	Antenna Tx Gain (dBi)	ACLR (dB) in 8 MHz bandwidth for emissions in 2470 to 2500 MHz	ACLR (dB) in 8 MHz bandwidth for emissions in 2030 to 2055 MHz
'Standard' Base Station	36.0	18.0	90	83
TDD Base-Station operation in 2.6 GHz using the relaxed mask	25.0	0.0	35.5	n/a

A6.12 The adjacent channel leakage ratio for base-stations operating in the 2.6 GHz band is estimated from the revised maximum emissions requirement of - 45dBm/MHz within the 2470 to 2500 MHz band. The limit is integrated over an 8 MHz PMSE receiver bandwidth resulting in a maximum estimated received interference power of -36dBm. For a base-station operating with an EIRP of 54dBm, this equates to an ACLR of 90dB.

Similarly, the ACLR for base-stations operating in the 2010 MHz band is estimated from the emission requirement of -38dBm/MHz over the 2030 to 2050 MHz range integrated over an 8 MHz PMSE receiver bandwidth, resulting in an ACLR of 83dB.

A6.13 The maximum interference power from a restricted power TDD base-station using the relaxed mask is estimated in Table 15. Within an 8 MHz PMSE receiver bandwidth, this results in a maximum estimated received interference power of -10.5dBm, equating to an ACLR of 35.5dB. It should be noted that such base-stations will only be allocated a channel adjacent to the 2500 MHz boundary if the entire 2.6 GHz band is attributed for TDD use.

Table 15: Estimated interference power from any restricted block TDD operation in 2500 to 2505 MHz into adjacent channel 8 MHz PMSE receiver.

Offset from relevant block edge. For any restricted TDD operation in 2500 to 2505 MHz, lower block edge is 2500 MHz	Maximum mean EIRP density	Apportionment of assumed 8 MHz PMSE receiver within 2490 to 2500 MHz	Estimated maximum EIRP within PMSE receiver bandwidth
-20.0 to –5.0 MHz (lower block edge)	–22dBm/MHz	4 MHz	-16dBm
–5.0 to –1.0 MHz (lower block edge)	–18dBm/MHz	4 MHz	-12dBm
–1.0 to –0.2 MHz (lower block edge)	$-19 + 15(\Delta_F + 0.2)$ dBm/30kHz	0	-
–0.2 to 0.0 MHz (lower block edge)	–19dBm/30kHz	0	-

A6.14 For the 2010 MHz band there are no restricted award channels defined and therefore no provision is provided for a relaxed mask. Therefore the operation of any low power base-stations in the 2010 MHz band will need to comply with the requirement of -38dBm/MHz within the 2030 to 2050 MHz range.

A6.15 For consistency, as assumed in the previous Ofcom analysis, results are presented for interference into non-airborne PMSE receivers based on the use of the ITU-R outdoor pedestrian propagation model (ITU-R M.1225), while those for PMSE airborne use are based on free space path loss. The ITU-R M.1225 model estimates the propagation loss between isotropic antennas expressed as the sum of free space loss, a diffraction loss from rooftop to the street, and the reduction due to multiple screen diffraction past rows of buildings.

Table 16: Propagation Models and associated losses (Frequency 2600 MHz)

Propagation Loss Model	losses(dB) for distance(m)				
	10	50	100	500	1000
ITU-R M.1225 Pedestrian	71.4	99.4	111.4	139.4	151.4
Free Space Path	60.7	74.7	80.7	94.7	100.7

A6.16 The results presented below estimate the additional isolation (or margin) between a PMSE receiver and an FDD/TDD base station interferer. The results adopt the format presented in the Engineering Study Phase 2 Report by Mason. They show the additional isolation (or margin) estimated to avoid interference from a range of separation distances between different PMSE systems and adjacent channel FDD/TDD systems. Where the result is negative, the value represents an excess margin that exists between interferer and victim. For convenience, the colour red is used to highlight a requirement for additional isolation and green to indicate an excess margin

A6.17 Scenario 1. Adjacency at 2500 MHz Calculation based on PMSE ACS = 46dB; interference into an adjacent PMSE channel (i.e. centred at 2495 MHz).

Table 17 contains the results of the analysis at the 2500 MHz band adjacency for TDD base stations and the PMSE channel at 2490 to 2500 MHz.

It should be recalled that base station transmissions will only be assigned channels adjacent to the 2500 MHz boundary if the whole 2.6 GHz band is identified through the award process for unpaired use. Under such circumstances the closest standard power base-station transmission to the 2500 MHz boundary will be the 5 MHz carrier at 2505 to 2510 MHz, resulting in a 12.5 MHz offset between the centre of the PMSE carrier and centre of the closest standard base-station 5 MHz carrier. In this case the results presented below for the base-station interference could well have considered a higher value of PMSE receiver ACS than the 46dB that is assumed here, which is based on 7.5 MHz offset between carriers, making the assessment conservative.

Table 17: Additional coupling loss or margin to meet PMSE interference criterion. Estimated unwanted emissions in adjacent PMSE channel. PMSE ACS = 46dB

Scenario		Additional Isolation or Margin (dB)					Separation (m)
Interferer	Victim	10	50	100	500	1000	
TDD Base Station (standard mask – 12.5 MHz separation)	Radio Camera 1W	44.1	16.1	4.1	-23.9	-35.9	126
	Portable/Mobile links	52.1	24.1	12.1	-15.9	-27.9	200
	Airborne links	62.6	48.6	42.6	28.6	22.6	Note 1
	Temporary point to point	64.1	36.1	24.1	-3.9	-15.9	400
TDD Base Station (relaxed mask – 7.5 MHz separation)	Radio Camera 1W	25.9	-2.0	-14.1	-42.0	-54.1	44
	Portable/Mobile links	33.9	6.0	-6.1	-34.0	-46.1	71
	Airborne links	44.5	30.5	24.5	10.5	4.5	Note 1
	Temporary point to point	45.9	18.0	5.9	-22.0	-34.1	141

Note 1: Calculation does not account for typical pattern losses between base station and airborne PMSE receivers, as considered further in the Engineering Study Phase 2 Report

A6.18 Scenario 2. Adjacency at 2500 MHz. Calculation based on PMSE ACS = 86dB; interference into an adjacent PMSE channel (i.e. centred at 2495 MHz).

If a suitable pass band filter is employed then the PMSE ACS can be considered to be improved by a minimum of 40dB over the baseline results presented in Scenario 1. The revised coupling results are presented in Table 18.

Table 18: Additional coupling loss or margin to meet PMSE interference criterion. Estimated unwanted emissions in adjacent PMSE channel. PMSE ACS = 86dB

Scenario		Additional Isolation or Margin (dB)					Separation (m)
Interferer	Victim	10	50	100	500	1000	
TDD Base Station (standard mask – 12.5 MHz separation)	Radio Camera 1W	5.5	-22.4	-34.5	-62.4	-74.5	14
	Portable/Mobile links	13.5	-14.4	-26.5	-54.4	-66.5	22
	Airborne links	24.1	10.1	4.1	-9.9	-15.9	Note 1
	Temporary point to point	25.5	-2.4	-14.5	-42.4	-54.5	43
TDD Base Station (relaxed mask – 7.5 MHz separation)	Radio Camera 1W	25.6	-2.4	-14.4	-42.4	-54.4	44
	Portable/Mobile links	33.6	5.6	-6.4	-34.4	-46.4	69
	Airborne links	44.1	30.1	24.1	10.1	4.1	Note 1
	Temporary point to point	45.6	17.6	5.6	-22.4	-34.4	138

Note 1: Calculation does not account for typical pattern losses between base station and airborne PMSE receivers, as considered further in the Engineering Study Phase 2 Report

A6.19 Scenario 3. Adjacency at 2030 MHz. Calculation based on PMSE ACS = 46dB; interference into an adjacent PMSE channel (i.e. centred at 2035 MHz).

Table 19 contains the results of the analysis at the 2030 MHz band adjacency for a 12.5 MHz offset between centre frequencies of an award channel at 2020 to 2025 MHz, and the PMSE channel at 2030 to 2040 MHz. As for the 2500 MHz boundary, the results presented below for the base-station interference could well have considered a higher value of PMSE receiver ACS than the 46dB assumed, which is based on 7.5 MHz offset between the centre frequencies of a PMSE carrier and a 5 MHz adjacent carrier.

It should be noted the differences in the results between scenario 1 and scenario 3 (estimating separation distances without use of a PMSE channel filter) are in the main due to the lower path loss at 2030 MHz compared to at 2500 MHz.

Table 19: Additional coupling loss or margin to meet PMSE interference criterion. Estimated unwanted emissions in adjacent PMSE channel. PMSE ACS = 46dB

Scenario		Additional Isolation or Margin (dB)					Separation (m)
Interferer	Victim	10	50	100	500	1000	
TDD Base Station (12.5 MHz separation)	Radio Camera 1W	46.8	18.8	6.8	-21.2	-33.2	148
	Portable/Mobile links	54.8	26.8	14.8	-13.2	-25.2	234
	Airborne links	64.4	50.4	44.4	30.4	24.4	Note 1
	Temporary point to point	66.8	38.8	26.8	-1.2	-13.2	467

Note 1: Calculation does not account for typical pattern losses between base station and airborne PMSE receivers, as considered further in the Engineering Study Phase 2 Report

A6.20 Scenario 4. Adjacency at 2030 MHz. Calculation based on PMSE ACS = 86dB; interference into an adjacent PMSE channel (i.e. centred at 2035 MHz).

If a suitable pass band filter is employed, then the PMSE ACS can be considered to be improved by a minimum of 40dB over the baseline results presented in Scenario 3. The revised coupling results are presented in Table 20.

Table 20: Additional coupling loss or margin to meet PMSE interference criterion. Estimated unwanted emissions in adjacent PMSE channel. PMSE ACS = 86dB

Scenario		Additional Isolation or Margin at 7.5 MHz offset between carriers (dB)					Separation (m)
Interferer	Victim	10	50	100	500	1000	
TDD Base Station (12.5 MHz separation)	Radio Camera 1W	11.5	-16.4	-28.5	-56.4	-68.5	19
	Portable/Mobile links	19.5	-8.4	-20.5	-48.4	-60.5	31
	Airborne links	29.2	15.2	9.2	-4.8	-10.8	Note 1
	Temporary point to point	31.5	3.6	-8.5	-36.4	-48.5	61

Note 1: Calculation does not account for typical pattern losses between base station and airborne PMSE receivers, as considered further in the Engineering Study Phase 2 Report.

Background to the selection of out-of-band limits

A6.21 The derivation of base station out-of-band limits for the 2010 MHz band is based on the premise that such emissions should not to cause a significant additional increase in the received adjacent channel interference from that arising through PMSE receiver selectivity.

A6.22 We have taken this to equate to a maximum 1dB increase in any received interference. This requirement equates to the ALCR performance parameter of the base station to be 6dB lower than the ACS performance of the PMSE receiver.

A6.23 In deriving the unwanted emissions limit, we assume the PMSE receiver ACS performance is 86dB to a base-station interferer then this results in an ACLR requirement for base-station emissions of 92dB. For a maximum base-station in-band power spectral density of 61dBm/(5 MHz), the maximum out of band emission requirements equate to -38dBm/MHz.

Annex 7

Co-ordination of services with France and Ireland

Ireland

A7.1 In Ireland the band 2500 to 2686 MHz is used for the Multichannel Multipoint Distribution Service (MMDS)[249] [250] [251] [252] [253] [254]. Information about these transmitters was given in the December 2006 Consultation and the August 2007 Discussion Document.

A7.2 UPC Ireland operates both analogue and digital distribution services at present but is currently undertaking a programme to convert the analogue services to digital.

A7.3 The December 2006 Consultation suggested that a large part of the UK might be effected by interference from the MMDS network, based on a receiver height of 20m, a receive path gain of 18dBi, protection to -110dBm and a 1% propagation model[255].

A7.4 However an alternative view was presented in the Discussion Document which showed smaller areas of the UK subject to interference.

A7.5 The Discussion Document also presented measurements which showed little or no measured interference from MMDS transmitters into north west England[256].

France

A7.6 The December 2006 Consultation and the Discussion Document presented information about the potential for IMT type transmitters in Northern France to deposit signal strength in the UK showing the area around the south east coast where signals of around 21 and 37 dBµV/m may be anticipated. The December 2006 Consultation and the Discussion Document also indicated the regions of the UK where coordination of transmitters with France may be anticipated.

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[249] Television Transmission Licensing For Cable and MMDS Systems Report on the Consultation Document No. ODTR 98/63 23 December 1998.
[250] MMDS TV Licence, Wireless Telegraphy Act, 1926, amended programme services distribution licence issued pursuant to the Wireless Telegraphy Act, 1926, and the Wireless Telegraphy (programme services distribution) Regulations, 1999, ODTR 99/81 July 1999 (effective from 19/04/99).
[251] Technical Conditions for the operation of analogue programme services distribution systems in the frequency band 2500-2686 MHz. ComReg 98/65R2, 9 June 2004.
[252] Technical Conditions for the operation of digital programme services distribution systems in the frequency band 2500-2686 MHz. ComReg 98/67R2, 9 June 2004.
[253] Future Strategy for MMDS in the 2.5GHz band. ComReg statement.
[254] Proposed Acquisition by UPC Ireland B.V. of MS Irish Cable Holdings B.V., M/05/024 UGC (Chorus) / NTL, Determination of the (Republic of Ireland) Competition Authority, 4th November 2005.
[255] 2010-2025 MHz, 2290-2302 MHz, 2500-2690 MHz, Spectrum Awards Technical Study Adjacent and In-Band Compatibility Assessment for 2500-2690 MHz 11 Dec 2006.
[256] Ofcom Report Number: ML2/004/05 Field Strength measurements in the 2.5 – 2.69 GHz band from emissions in the Republic of Ireland and France.

Further analysis of transmitters in France

A7.7 Since publication of the Discussion Document we have been informed by the Agence Nationale des Fréquences (ANFR) that currently in France the band 2500 to 2690 MHz is used for tactical radio relay links and the band 2500 to 2520 MHz is used for radiolocation services (radar).

A7.8 The bands will be made progressively available for electronic communication mobile services. The date for the change to electronic communication mobile services is not precisely defined, and is subject to discussion concluding between the French Regulatory authorities and the operators, but it may be completed by 2012.

A7.9 We have received from the ANFR further assessment of the impact in the UK of the French fixed links and radar service.

A7.10 For the point to point services, as currently operated, a 21 dBµV/m threshold is not exceeded at and beyond the UK coastline, with propagation according to Recommendation ITU-R P.1546-3, for 10% of time, 50% of locations and at a receive height of 3m.

A7.11 Some radars are currently operating in northern France with field strengths which may exceed 21dBµV/m in the UK. These radars operate in frequencies below 2500 MHz. However the band 2500 to 2520 MHz may also be used in cases of national emergency. These radars operate continuously with a 360° sweep.

A7.12 Other radars which operate in the frequency band 2500 to 2520 MHz will not be used at any location in France that would cause a field strength at the UK coast line to be greater or equal than 21dBµV/m, except in cases of national emergency.

Background to the Memorandum of Understanding

A7.13 Ofcom has given consideration to coordination requirements and processes set out in MoUs for the frequency band 2500 to 2690 MHz between UK and Ireland and UK and France. The technical conditions for coordination described in the MoUs and agreed with neighbour administrations are a compromise between the need to protect potential services, give certainty to potential licensees and take into account the opinions of the neighbour administration.

A7.14 The frequency band 2500 to 2690 MHz has been discussed within EC and CEPT in the context of WAPECS[257]. The RSC Decision on the 2.6 GHz band adopted on 2 April 2008 as well as any EC derogation on a transitional period in France (under the RSC Decision) may change coordination requirements.

A7.15 The technical conditions for coordination described in the MoUs are not a restriction on transmitter power; they are a 'trigger point' which is used to initiate discussions with neighbour administrations and operators.

A7.16 ERC Recommendation 01-01[258] makes provision for the coordination of UMTS services. However this does not address the more general case where the nature

[257] EC Mandate to CEPT to develop least restrictive technical conditions for frequency bands addressed in the context of WAPECS', 5 July 2006.

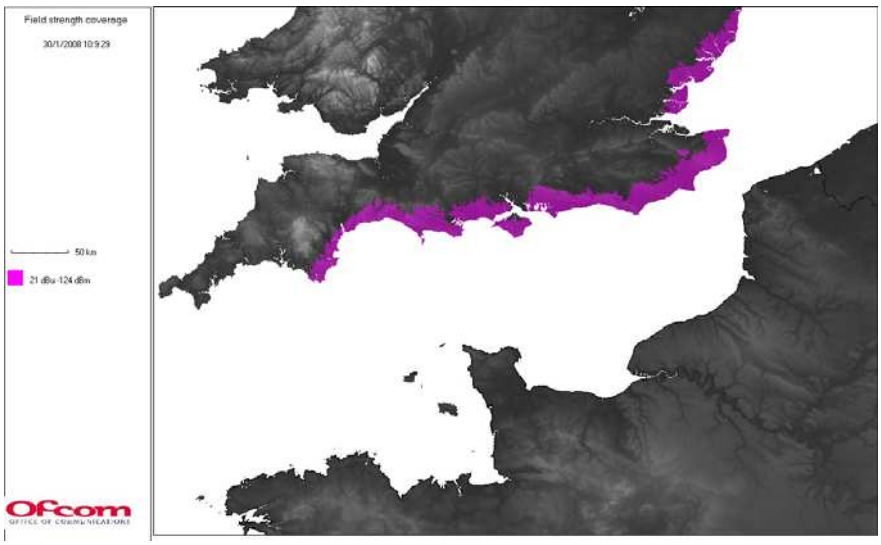
[258] Electronic Communications Committee (ECC) within the European Conference of Postal and Telecommunications Administrations (CEPT), ERC Recommendation 01-01 (revised Dublin 2003, Helsinki 2007), Border Coordination of UMTS

of the technology is largely undetermined. Ofcom has agreed with our neighbour administrations a single coordination trigger for the bands 2500 to 2690 MHz of 21dBµV/m in a bandwidth of 5 MHz; with a propagation model according to the latest version of Recommendation ITU-R P.1546[259], for 10% of the time at 50% of locations and a receiver height of 3m, in line with CEPT Report 19. This is equivalent to a noise level of -204dBW/Hz at a receiver input with a receive path gain of 16dBi as described in the Discussion Document[260].

A7.17 Propagation model ITU-R P.1546 has been proposed for the MoUs in preference to model ITU-R P.452[261]. ITU-R P.452 is primarily designed for point to point services and does not incorporate spatial averaging. Consequently stations many kilometres from the border may require coordination.

A7.18 An indication of the region of the UK near to France where coordination may be anticipated for a nominal 60 dBm EIRP transmitter at 20m above ground level is given in Figure 20 below.

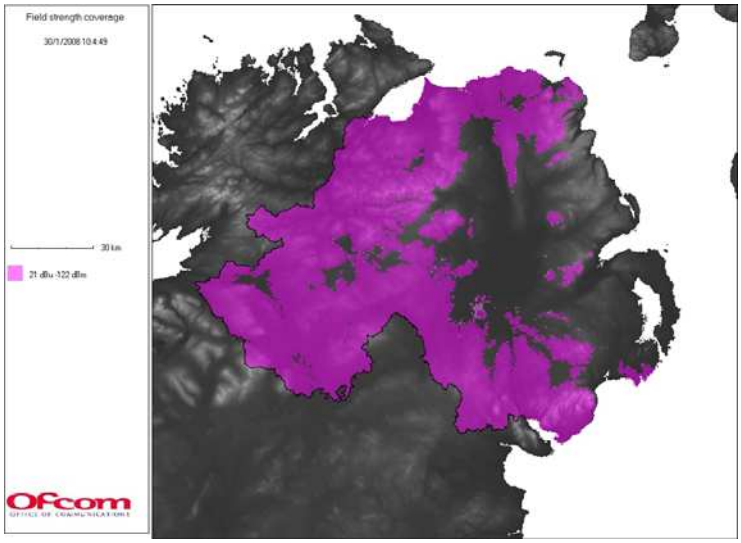
Figure 20: Region of the UK where coordination of radio services with France is anticipated



A7.19 An indication of the region of the UK near to Ireland where coordination may be anticipated for a nominal 60 dBm EIRP transmitter at 20m above ground level is given in Figure 21 below.

[259] Recommendation ITU-R P.1546, Method for point-to-area predictions for terrestrial services in the Frequency range 30 MHz to 3 000 MHz
[260] August discussion document Table 73
[261] Recommendation ITU-R P.452, Prediction procedure for the evaluation of microwave interference between stations on the surface of the Earth at frequencies above about 0.7 GHz

Figure 21: Region of Northern Ireland where coordination of radio services with the Republic Of Ireland is anticipated



A7.20 Transmitters which exceed the trigger level will be coordinated with the neighbour administration in accordance with the procedures established in the Berlin Agreement (revised at Vilnius) Annex 2A[262].

A7.21 The MoU will make provision for operators to make arrangements between themselves, subject to the approval of the administrations and other parties who may be affected by such arrangements. For example operators may mutually agree to use the trigger levels derived ERC Recommendation 01-01 in situations where UMTS FDD/TDD services are frequency aligned opposite similar services.

A7.22 In the case of Ireland the MoU includes a table giving the parameters of the MMDS transmitters near the Ireland-NI border, this reflects the essential characteristics of the MMDS network at the time of signing the MoU. Any further changes to the MMDS network, for example a new transmitter or power increase, will be subject to the procedures described in the MoU.

A7.23 Some of the digital MMDS transmitters are currently operating at powers less than the power indicated in the MoU in order to limit interference between the digital and analogue networks. It is anticipated that that the digital transmitters will operate at the powers indicated in the MoU when the analogue network closes.

[262] Agreement between the Administrations of … on the Coordination of frequencies between 29.7 MHz and 39.5 GHz for fixed service and land mobile service (HCM Agreement) Vilnius, 2005
http://hcm.bundesnetzagentur.de/http/englisch/verwaltung/index_europakarte.htm

Annex 8

Adjacency with Globalstar

A8.1 This Annex presents a revised assessment of the potential for interference into Globalstar receivers from base-stations operating in the 2.6 GHz band. It is based the methodology presented by Globalstar in their response to the Discussion Document, which made use of a propagation model based on that presented within Annex 12 of the December 2006 Consultation.

A8.2 The parameters assumed within this analysis are listed in Table 21 and Table 22.

Table 21: Globalstar terminal interference levels

Globalstar assumed sensitivity to OOB Interference	
Maximum level of Interference	-129.1dBm
Antenna gain to interferer	0 dBi
Assumed antenna height	1.5 m

Table 22: Base-station transmitter parameters

Transmitter Parameters	Antenna Height	Interference limit in the band 2470 to 2500 MHz
'standard' Base Station	20.0	-45dBm /MHz
'restricted' TDD Base-Station operation in 2.6 GHz	4	-22dBm /MHz

A8.3 A minimum coupling loss is estimated using a dual slope propagation model based on that contained in Annex 12 of the December 2006 Consultation. This assumes free space path loss up to a distance, d_0, and then an increased rate of path-loss / extended roll-off thereafter. The propagation model assumed is provided in the equation below (Dual Slope Propagation Model based on that used in Annex 12, December 2006 Consultation).

$$L_{DS} = L_{FS}(d) + L_N(B) \qquad \text{for } d \le d_0$$

$$L_{DS} = L_{FS}(d_0) + A.10.\log_{10}\left(\frac{d}{d_0}\right) \qquad \text{for } d > d_0$$

where:

$$L_{FS} = 32.45 + 20\log_{10}(f_{MHz}) + 20.\log_{10}(d_{km})$$

And coefficients d_0 and A defined in Table 23 as follows:

Table 23: Propagation coefficients

TX-RX Heights	High-Low	Low-Low
Break point (d_0)	100 m	50 m
Extended Roll-off (A)	3.5	4

A8.4 The results of the revised assessment are presented in Table 24. The calculation considers the effect of out-of-band emissions falling within the Globalstar receiver pass-band. The second column is a check calculation with the results of the 'FDD D/L' scenario presented within the Globalstar response to the Discussion Document.

Table 24: Globalstar terminal interference levels

	Globalstar Check	Base-station OOB emissions		
Emissions requirement	-5.9	-45	-22	dBm/MHz
Globalstar receiver BW	1.23	1.23	1.23	MHz
OOB in receiver BW	-5.0	-44.1	-21.1	dBm
Assumed Globalstar permissible interference criterion.	-129.1	-129.1	-129.1	dBm
Assumed receiver gain to unwanted signal	0	0	0	dBi
Required system isolation loss	124.1	85.0	108.0	dB
Duel slope propagation model	High-Low	High-Low	Low-Low	
Estimated MCL distance	1.77	0.14	0.35	km