OFFICE OF COMMUNICATIONS

Digital Dividend Review: 550-630 MHz and 790-854 MHz

Consultation on detailed award design

Consultation

Publication date:	6 June 2008
Closing Date for Responses:	15 August 2008

Contents

Section		Page
1	Executive summary	2
2	Introduction	9
3	Legal framework	12
4	Availability and uses of the cleared spectrum	17
5	Technical licence conditions	34
6	Non-technical licence conditions	65
7	Spectrum packaging	79
8	Auction format and rules	110
9	Promoting competition and efficiency	148
10	Next steps	174

Annex		Page
1	Responding to this consultation	175
2	Ofcom's consultation principles	177
3	Consultation response cover sheet	178
4	Consultation questions	180
5	Impact assessment	184
6	Practical implementation of licence conditions	200
7	Interference between new services in the cleared spectrum	208
8	Interference into and from existing DTT services – additional technical studies	215
9	Interference between new services and international radio astronomy services	221
10	Technical licence conditions in terms of SURs	226
11	Glossary of abbreviations	228

Section 1

Executive summary

1.1 This consultation document launches the implementation phase of the digital dividend review (DDR). In this document we set out our proposals on the packaging and auction design for the digital dividend cleared award together with our approach on conditions to be included in the licences that will be awarded at auction.

1.2 Two other consultation documents, which we expect to publish shortly will set out our proposals for the auction for the DDR geographic interleaved spectrum and for the beauty contest for the remaining interleaved spectrum for the award of a licence for a band manager with obligations to Programme Making and Special Events (PMSE) users.

1.3 Our aim in designing these awards is to facilitate the release of this important resource in a manner which not only reflects existing consumer demand and the technological advances made in wireless communications over recent years, but also allows this spectrum to change use and adapt to changing consumer demand and developments in technology.

1.4 Experience of spectrum awards in the UK and elsewhere suggests that a well-designed auction can be a powerful tool for encouraging new entry, new services and new technologies. An important part of the proposals set out in this document is our consideration of awarding the DDR spectrum in a manner that can best promote competition and innovation in downstream markets.

Our objective

1.5 Our objective for the DDR is to maximise the total value to society that using the digital dividend may generate over time. It is not our objective to raise revenue for the Exchequer, nor is this a consideration that we can take into account, given our statutory duties.

1.6 Over the past two years, we have consulted on our strategic approach to the release of the DDR spectrum. We have concluded that we should take an approach that puts the market at the centre of decision-making, rather than the regulator.

1.7 This means that for the most part it will be users, not regulations, that decide how, for what, and by whom the spectrum should be used, subject mainly to technical conditions designed to prevent harmful interference.

The cleared spectrum

1.8 This document concerns the release of the single largest group of spectrum bands considered in the DDR, known as the cleared spectrum. This comprises 128 MHz of spectrum that will be cleared of existing uses UK-wide by, at the latest, late 2012.

1.9 This 128 MHz comprises in turn 112 MHz of spectrum that will be released as a consequence of digital switchover; 8 MHz that will be released by clearing aeronautical radar from channel 36; and an additional 8 MHz that will be cleared as a result of the decision by the authorities responsible for UK's radio astronomy to place channel 38 in the DDR cleared award.

1.10 This spectrum forms two large contiguous blocks. One runs from 550-630 MHz. The other from 806-854 MHz. In addition, we propose to award in the same auction rights to 16 MHz of interleaved spectrum that is adjacent to one of these two blocks, at 790-806 MHz.

1.11 Our research shows that there is a wide variety of potential uses for this spectrum. The most likely uses include mobile multimedia services (Mobile TV), mobile broadband (including two way mobile services), and Digital Terrestrial TV (both in Standard and High Definition).

1.12 Consistent with our wider strategy, this document sets out how we plan to release the spectrum in a way that will allow the widest possible range of technologies and services to take part in the award. It also describes how we propose to make the licences tradable so that the identity of users and the type of use can change over time, reflecting changes in technology and the preferences of citizens and consumers.

Timing of the award

1.13 We propose to award the cleared spectrum as soon as possible. We consider that the auction could begin in summer 2009, consistent with the proposals in this document.

1.14 This timing will give the market the maximum opportunity to make use of the spectrum as soon as possible. It will also mean that providers can begin to offer new services with the minimum delay following the cessation of existing uses. This should help to maximise the benefits to citizens and consumers from potential extra competition and innovation.

1.15 We do not think it is likely to be desirable to delay the award of this spectrum artificially beyond this date. We judge that the market is better placed than the regulator to decide the use of spectrum, and that an auction to this timescale would offer a fair opportunity for participation by the wide range of potential bidders. These parties would be able to take into account in their decisions all the information available to them at the time; and the award design proposed here would help to ensure that these decisions were efficiently reflected in the auction outcome.

1.16 We will however continue to take into account developments at EU level in taking decisions on the timing and other aspects of the award. This is in particular because of the scope for European legislative action which could have a binding effect on the UK.

1.17 At present, the nature and content of further action at EU level is unclear. The European Commission has said that it plans to set out a regulatory road map on the digital dividend in late 2008. Any Commission proposals are likely to be influenced by the outcome of discussions in the European Parliament and Council where the issue of the Digital Dividend is currently being addressed. We will keep these developments under review.

1.18 As set out in the DDR Statement, we strongly support a non-mandatory approach to harmonising the digital dividend in the EU. This will allow Member States to participate to the extent that they wish while not favouring one use of the digital dividend over others.

Detailed proposals

1.19 The table below sets out a summary of our detailed proposals for this award:

Table 1.1 Summary of detailed proposals

Available Spectrum	**Our proposals for consultation**
Spectrum included in the cleared award	The cleared award will include the following spectrum bands: • 112 MHz of spectrum cleared on a UK-wide basis as a result of DSO; • 8 MHz of spectrum cleared on a UK-wide basis as a result of aeronautical radar ceasing to use channel 36 in March 2009; • 8 MHz of spectrum cleared on a UK-wide basis as a result of UK radio astronomy ceasing to use channel 38 in 2012; and • 16 MHz of interleaved spectrum in channels 61 and 62. The cleared spectrum comprises two blocks of contiguous spectrum: 550-630 MHz and 806-854 MHz. The interleaved spectrum comprises 790-806 MHz.
Timing	**Our proposals**
Timing of the cleared award	We propose to hold the cleared award so that the award begins in Summer 2009
Continued PMSE access to cleared spectrum	We consider whether to increase the notice period for ending temporary PMSE access to channels 63-68 from 6 to 12 months. We also consider whether to offer temporary access to channels 31-40.
London 2012 Olympic Games and Paralympic Games	We suggest that rights awarded to the spectrum cleared as a result of DSO in London could begin after the London 2012 Olympic Games and Paralympic Games have been concluded.
Technical licence conditions (TLCs)	**Our proposals**
Type of TLCs	We propose to define the TLCs for the available spectrum in the form of Spectrum Usage Rights (SURs). The SURs will be tailored to the different transmission network types that are likely to be deployed in the spectrum.
Guard bands	We suggest guard bands will be needed between licences with different SUR types. Winners of licences will be able to negotiate with licensees in adjacent spectrum in order to modify the emission restrictions

	contained in the guard bands.
Protection of existing DTT services	To prevent interference to existing DTT services adjacent to the available spectrum, we propose to include a clause in every licence in the DDR Cleared Award. The clause would place an onus on the new licensees to plan network roll out to keep interference to existing DTT services to a minimum
Protection of radio astronomy (in UK to 2012; internationally before and after 2012)	To prevent interference to UK radio astronomy in channel 38, the winner(s) of spectrum in channels 37, 38 and 39 will be subject to TLCs which will prevent transmissions within defined geographical areas *up to 2012*. To prevent interference to international radio astronomy, the winner of spectrum in channel 38 will be subject to emission limits such that the spectrum will mainly be suitable for low power services (although potentially for high power services in the future if international restrictions on emissions were eased). Standard TLCs will be awarded to the winners of spectrum in channels 37 and 39 but network deployments in these channels is likely to be constrained in order to limit the emissions made outside UK borders.
Non- technical licence conditions	**Our proposals**
Multiplex ownership and interoperability	We propose to include certain restrictions on ownership in relation to use of cleared spectrum to operate new DTT multiplexes. These would reflect the similar regime under the Broadcasting Act (for example preventing religious or political bodies from holding licences for this purpose). We propose to facilitate technical interoperability between any new DTT services in cleared spectrum and existing DTT services.
Licence term	We propose that the licences should have an indefinite duration, with an initial term ending in 2026 during which Ofcom's powers to revoke will be limited. After the initial term Ofcom will have the power to revoke licences for spectrum management reasons on not less than 5 years' notice. This could lead to the licence being terminated the day after the expiry of the initial term or at any time thereafter.
Licence fees	The auction will determine the fees payable, subject to a reserve price. After the expiry of the initial term, if a licensee continues to hold its licence, there may be additional charges. In particular, to incentivise efficient use of the spectrum, we presently expect to charge AIP.

Spectrum trading	All licences in the cleared award should be tradable. All types of trade - partial or total; concurrent or outright - will be permitted.
Non-technical restrictions	The licences will not contain any non-technical restrictions on the use to which the spectrum could be put.
Information provision	The licences should contain provisions requiring licensees to provide us with information about spectrum usage.
Spectrum packaging	**Our proposals**
Frequency size of lots	Both 5 MHz and 8 MHz lots should be offered across the available spectrum.
Frequency specificity of lots	A mixture of frequency-specific and frequency-generic lots should be offered, grouped into around 35 categories.
Geographic scope of lots	All lots should be UK-wide in geographic scope.
Auction design	**Our proposals**
Auction format	We propose to use the combinatorial clock auction format (CCA) for the cleared award
Deposits	We propose that the initial deposit payable on application would be in the range £50,000 to £100,000 in this award. Further deposits will be required as the auction unfolds.
Qualification rules	The nature of the rules and penalties relating to collusion and bidder association are likely to be similar to those that we have put in place for other recent spectrum awards. As such, it is likely that we will notify each applicant of the names and associates of all other applicants and set a date by which applicants must notify us as to whether any members of their bidder group are also associates of another applicant. We are also likely to consider whether any members of one bidder group are also members of another bidder group.
Pace of the auction	We propose to retain discretion over the scheduling of primary bid rounds, which includes discretion over the number of rounds per day, together with retaining a level of discretion over round price increases in managing the duration of the auction.
Activity rules	We consider whether to use an ex ante eligibility points activity rule or a revealed preference activity rule for the cleared award and welcome stakeholders comments on this
Switching rules in primary bid rounds	We consider whether to restrict the ability of bidders to switch demand during the auction to different TLC types.

Information made available in primary bid rounds	At the end of each primary bid round, we propose to reveal to each bidder the aggregate demand for lots by category. We may also allow bidders to obtain information about anonymised individual demand in previous rounds.
Base price and additional price determination	We expect base prices and additional prices to be calculated using a second price rule
Limits on supplementary bids	For supplementary bids for packages which had eligibility points above the bidder's activity in the final primary bid round, the bid amount is likely to be capped at the price that would have applied to that package in the round where the bidder was last eligible to bid for the package concerned.
Competition and efficient use of spectrum	**Our proposals**
'Use it or lose it' conditions	We propose not to impose 'use it or lose it' conditions.
Roll-out obligations	We propose not to impose any roll-out obligations.
Access requirements	We propose not to impose access requirements.
Spectrum caps	We propose to cap the maximum volume of spectrum that can be acquired by any one participant in the cleared award at 50 MHz
Sub 1 GHz spectrum for mobile broadband	We consider ways to address competition concerns relating to operators holding large amounts of spectrum below 1 GHz suitable for mobile broadband services. We ask for views on whether a 'soft' spectrum cap might be a suitable remedy.

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

Next steps

1.20 This consultation will close on 15 August 2008. We also expect to hold a seminar on these proposals in early July 2008 for stakeholders during the consultation period.

1.21 During the consultation period, we also intend to engage with key stakeholders on the practical implementation of our proposals on the protection clause

1.22 Subject to the conclusion of this consultation, we believe it to be prudent to plan on the basis of a second detailed consultation focussed on outstanding technical and engineering issues in Autumn 2008.

1.23 Table 1.2 below therefore sets out the current timetable for holding the cleared award.

Table 1.2 Timetable for the DDR cleared award

May 2008	First consultation on detailed award design
Summer 2008	First consultation closes
Late autumn 2008	Second consultation on detailed award design
Winter 2008	Second consultation closes
Late spring 2009	Information memorandum and draft regulations
Summer 2009	Award begins

Section 2

Introduction

2.1 The first phase of the Digital Dividend Review (DDR) concluded with the publication of a statement in December 2007 (the DDR statement).[1] In it, we set out our decisions on the strategic approach we would take to the release of the UK's digital dividend – the spectrum freed up by digital switchover (DSO). Some of those key decisions were as follows.

- We confirmed our proposal to take a market-led approach to awarding the digital dividend, giving users the flexibility to decide its use.
- We decided not to intervene to reserve the spectrum for any particular use, and to award the spectrum by auction. The one exception to this approach was in relation to a package of interleaved spectrum, which we decided to award with obligations toward programme-making and special events (PMSE), and to award via a beauty contest.
- We decided to auction geographic packages of interleaved spectrum suitable but not reserved for local television.
- We proposed to allow licence-exempt cognitive access to the interleaved spectrum but decided not to set aside any of the digital dividend exclusively for licence-exempt use or as an innovation reserve.
- We decided to include channel 36 in the award of the cleared spectrum and proposed to award the interleaved spectrum in channels 61 and 62 alongside this spectrum.
- Finally, we decided to continue with our timetable of awarding the digital dividend as soon as possible, which means that we envisage awarding the cleared spectrum in Summer 2009.

2.2 This consultation document is one of three consultation documents. The other two documents which we will publish shortly will set out our proposals on the detailed design of the award of geographic packages of interleaved spectrum and of the award of a single package of interleaved spectrum with PMSE obligations. Later this year, we will publish a further consultation document which will set out our proposals on licence-exempt cognitive access to the interleaved spectrum.

2.3 This document focuses on our proposals for the detailed design of the DDR cleared award, i.e. the cleared spectrum in the bands 550-630 MHz and 806-854 MHz and the interleaved spectrum in the band 790-806 MHz.[2] Further details of this spectrum can be found in section 4, where we discuss the availability and potential uses of this spectrum. In the remainder of this document, we specifically consider:

- the constraints on the spectrum to be awarded and its most likely potential uses;

[1] http://www.ofcom.org.uk/consult/condocs/ddr/statement/statement.pdf

[2] In the remainder of this document, we use the term "cleared award" to refer to the award of all of the spectrum described here.

- the choice of technical licence conditions that provide flexibility to implement a wide range of different services and technologies while affording sufficient protection from harmful interference for spectrum users;

- the choice of non-technical usage rights and obligations, including the licence term and the ability to trade spectrum, that will apply to licensees;

- the definition of packages of rights and obligations that best reflect the demand for the spectrum and its specific technical constraints;

- the selection of an auction format and rules that provide the best fit for the available packages of spectrum; and

- how the award can best promote competition and efficiency in downstream markets.

2.4 Throughout the DDR, we have undertaken detailed market and stakeholder research to gain a better understanding of the demand for the digital dividend. Between March and April of this year, we appointed consultants to undertake stakeholder research to update our December 2006 research on the demand for the digital dividend. The results are summarised in section 4. Our proposals reflect our understanding of the most likely uses of the spectrum.

2.5 Our objective in awarding the digital dividend is to maximise the total value to society using this spectrum is likely to generate over time. It is not our objective to manage the spectrum so as to raise revenue for the Exchequer – nor, given our statutory duties, is this a consideration that we take into account.

2.6 The success of the award process that we are designing in this phase of the DDR is critical to realising the benefits of this spectrum. Our market and stakeholder research demonstrates that there is a wide range of potential uses for this spectrum that are likely to deliver significant benefits. These can be delivered through the launch of new, innovative services or by increasing competition among those services already available and highly valued by citizens and consumers alike.

2.7 Experience from past spectrum awards has suggested that our proposals for detailed award design need to be tailored to the specific characteristics of the spectrum in question.

2.8 Therefore, our task in designing the DDR cleared award is to:

- devise the most appropriate set of technical licence conditions that will protect existing and new users of the spectrum from harmful interference while at the same time providing maximum flexibility for many different potential uses of the spectrum to coexist, thereby preserving the inherent value of this valuable natural resource;

- choose the most appropriate non-technical licence conditions to provide certainty of tenure for winners of spectrum and enable maximum flexibility for the spectrum to pass to those who value it most over the course of time;

- define packages of these licence rights and obligations for assignment by auction that best reflect the demand for the spectrum and its specific technical constraints; and

- design an efficient auction process that promotes competition and efficiency enabling bidders to express their true value for the spectrum and encouraging innovation in the form of new entry, new services and new technologies.

Structure of this document

2.9 This document is structured as follows.

- In section 3, we set out the legal framework within which we operate.
- In section 4, we explain our understanding of the demand for the spectrum to be awarded and our position on the timing of the award.
- In section 5, we set out our assessment of the technical licence conditions that we propose to apply to this spectrum.
- In section 6, we set out the non-technical licence conditions we propose to include in the licences that we will award to successful bidders following the auction of this spectrum.
- In section 7, we describe a number of key choices that must be made in determining the packages of rights and obligations we will make available through the licences.
- In section 8, we make proposals for the design of an auction that will assign the packages proposed in section 7 in a way that best meets our objective for the DDR.
- In section 9, we explain why competition and efficiency are so important, how our general approach to awarding and managing spectrum is designed to promote both competition and efficiency.
- In section 10, we set out the next steps for this award, including an overview of the timetable for all three DDR awards.

Section 3

Legal framework

3.1 In this section, we describe our functions, duties and objectives as they relate to these awards. We also provide a brief overview of the international provisions that impact on the potential future uses of the digital dividend.

Our functions, duties and objectives

3.2 We make decisions within a framework defined in European Union (EU) and UK law. This sets out overarching general duties that apply across all our functions, below which sit a number of specific duties.[3]

The duties imposed by the Communications Act 2003

3.3 Section 3 of the Communications Act 2003 sets out our general duties and provides that our 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.

3.4 In securing the above duties, we are required to secure among other things the optimal use for wireless telegraphy of the electromagnetic spectrum and the availability throughout the UK of a wide range of electronic communication services and to have regard to the different needs and interests of everyone who may wish to use the spectrum for wireless telegraphy.

3.5 Section 3(3) of the Communications Act provides that in performing our principal duties, we must in all cases have regard to the principles of transparency, accountability, proportionality and consistency as well as ensure that our actions are targeted only at cases in which action is needed.

3.6 Section 3(4) of the Communications Act requires us in performing our 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.

3.7 Where there is a conflict between our duties, priority must be given to the European Community requirements set out in Section 4.

European Community requirements

3.8 Section 4 of the Communications Act implements article 8 (policy objectives and regulatory principles) of Directive 2002/21/EC on a common framework for electronic communications networks and services (the Framework Directive). This sets out the objectives that national regulatory authorities must take all reasonable steps to achieve. These include the promotion of competition in the provision of electronic

[3] See annex 6 of the DDR statement for a more detailed overview of the statutory duties relevant to the DDR.

communications networks and services by, among other things, encouraging efficient investment in infrastructure and promoting innovation, and encouraging efficient use of radio frequencies; and contributing to the development of the internal market by, among 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.

3.9 Article 8 also requires EU 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.

Our duties when carrying out our spectrum functions

3.10 In carrying out our spectrum functions, we have a duty (under Section 3 of the Wireless Telegraphy Act 2006) to have regard in particular to:

- the extent to which the spectrum is available for use or further use for wireless telegraphy;
- the demand for use of that spectrum for wireless telegraphy; and
- the demand that is likely to arise in future for the use of that spectrum for wireless telegraphy.

3.11 We also have a duty to have regard, in particular, to the desirability of promoting:

- the efficient management and use of the spectrum for wireless telegraphy;
- the economic and other benefits that may arise from the use of wireless telegraphy;
- the development of innovative services; and
- competition in the provision of electronic communications services.

3.12 Where it appears to us that any of our duties in Section 3 of the Wireless Telegraphy Act conflict with one or more of our general duties under Sections 3 to 6 of the Communications Act, priority must be given to our duties under the latter. Section 5 of the Communications Act concerns our obligation to carry out our functions in accordance with any directions made by the Secretary of State. Section 6 concerns duties to review regulatory burdens.

Granting wireless telegraphy licences

3.13 The Wireless Telegraphy Act sets out our legal power to grant wireless telegraphy licences. Section 8(1) makes it an offence for any person to establish or use any station for wireless telegraphy or to install or use any apparatus for wireless telegraphy except under and in accordance with a licence granted by us under that Section (a wireless telegraphy licence).

3.14 Section 9(1) of the Wireless Telegraphy Act gives us the power to grant wireless telegraphy licences subject to such terms as we think fit.

3.15 However, our broad discretion in relation to the terms that can be imposed in a wireless telegraphy licence is subject to the rule that we must impose only those terms that we are satisfied are objectively justifiable in relation to the networks and services to which they relate, not unduly discriminatory and proportionate and transparent as to what they are intended to achieve (see Section 9(7)).

3.16 Under Section 8(4) of the Wireless Telegraphy Act, we have the duty to exempt from licensing any use of wireless telegraphy apparatus that we consider is not likely to cause harmful interference. Licence exemptions are granted by way of regulations made under Section 8(3).

Providing for an auction of wireless telegraphy licences

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

3.18 Under Article 7(2) of the Authorisation Directive, where the number of rights of use of radio frequencies needs to be limited, Member States' selection criteria must be objective, transparent, non-discriminatory and proportionate. Section 29 of the Wireless Telegraphy Act requires us to make an order setting out the criteria.

3.19 Within this context, we have the power under Section 14 of the Wireless Telegraphy Act (having regard to the desirability of promoting the optimal use of the electromagnetic spectrum) to make regulations providing that applications for the grant of wireless telegraphy licences must be made in accordance with a procedure that involves the applicants making bids for licences (e.g. an auction).

3.20 We have broad powers under Section 14 to make provision in regulations for the form of the licences and the auction bidding procedure.

Charging fees for wireless telegraphy licences

3.21 Under Article 13 of the Authorisation Directive, any fees imposed for rights of use of radio frequencies must reflect the need to ensure the optimal use of the resources. Such fees must be objectively justifiable, transparent, non-discriminatory and proportionate in relation to their intended purpose and take into account the objectives set out in Article 8 of the Framework Directive.

3.22 Section 12 of the Wireless Telegraphy Act permits charging for wireless telegraphy licences by enabling us to prescribe in regulations sums payable for these licences. This power enables us to recover the cost of administering and managing wireless telegraphy licences. Section 13 of the Wireless Telegraphy Act permits us to recover sums greater than these if we think fit in the light (in particular) of the matters to which we must have regard under Section 3, including promoting the efficient management and use of the part of the electromagnetic spectrum available for wireless telegraphy.

3.23 The fees for most wireless telegraphy licences (including those fees that we set in order to incentivise the efficient use of the spectrum) are set out in specific regulations. The current regulations are the Wireless Telegraphy (Licence Charges) Regulations 2005 (SI 2005/1378) (as amended).

Objective for the DDR

3.24 Taking account of our duties and our spectrum management strategy, and as set out in the DDR consultation document and statement, our objective for the DDR is to maximise the total value to society that using the digital dividend is likely to generate over time. It is emphatically not our objective to award the digital dividend to maximise revenue for the Exchequer. Given our duties, this is not a consideration we take into account.

International Regulatory framework for electronic communications

3.25 Spectrum management in the UK takes place within international frameworks set both globally and in the EU. Under the Radio Spectrum Decision,[4] the European Commission can adopt Decisions governing spectrum use. This can be done in the interests of ensuring effective policy coordination and, where appropriate, harmonised conditions for spectrum use in the internal market. These Decisions are binding on Member States and can only be adopted by the Commission with the support of a qualified majority of them, convened as the Radio Spectrum Committee (RSC). We represent the UK at RSC under direction by the Government.

3.26 The Radio Spectrum Policy Group (RSPG) works in parallel with RSC and also draws its membership from Member States. Again, we represent the UK under direction by the Government. RSPG's role is to give strategic advice to the Commission on major questions of spectrum policy. It does this by adopting Opinions, which are not binding but can have significant influence as they represent the prevailing view of Member States.

3.27 Three recent developments are particularly relevant to the DDR cleared award.

3.28 First, the World Radiocommunication Conference 2007 (WRC-07) agreed in November 2007 to change the international Radiocommunication Regulations to make spectrum currently used for analogue television more flexible, in particular enabling mobile use.

3.29 This has limited direct effect on the UK because agreements with other European countries already give us substantial flexibility. But the indirect benefits of the agreement could be large, opening up the prospect that many more countries will make a digital dividend available for new wireless services. This will help to create global economies of scale for equipment, so increasing choice and reducing prices for UK consumers.

3.30 Second, and in the same month, the European Commission published a Communication on a common approach to the digital dividend in Europe.[5] This recommends identifying common bands that can be optimised by enabling "clusters" of services using a similar type of communications network: broadcasting, mobile multimedia and mobile broadband. These bands would be planned and harmonised in some form at EU level. The Communication was published at the same time as a package of proposals for amending the legislation defining the EU regulatory framework for electronic communications networks and services.

3.31 The Communication concludes by indicating that the Commission will prepare the required measures to reserve and coordinate the common bands at EU level if

[4] http://eur-lex.europa.eu/LexUriServ/site/en/oj/2002/l_108/l_10820020424en00010006.pdf.
[5] http://ec.europa.eu/information_society/policy/ecomm/doc/library/proposals/com_dd_en.pdf

necessary. Clearly, our award of the digital dividend will need to comply with any mandatory EU measures.

3.32 Third, the European Conference of Postal and Telecommunications Administrations (CEPT), in its response to a subsequent Commission mandate on this issue, concluded that the preferred sub-band for the harmonised mobile broadband cluster proposed by the Commission is the upper part of UHF band V and should include, as a minimum, channels 62-69 (798-862 MHz) as offering the best possibility for Europe-wide non-mandatory, non-exclusive harmonisation. This same spectrum including channel 61 (thus expanding the range to 790-862 MHz) was then subsequently the subject of decisions at World Radio Conference held in 2007 (WRC -07) to enhance flexibility for mobile usage.

3.33 Following a further Commission mandate, work continues within CEPT to identify common technical conditions and international coordination and channelling arrangements. These reports are expected to be available in draft form from the end of 2008, for final delivery by June 2009.

3.34 We expect the following key outputs in relation to the DDR cleared award to occur between now and March 2009:

- in June 2008, conclusions from the Council of Ministers on the Commission Communication;
- in September 2008, a report from the European Parliament on the Commission Communication; and
- in March 2009, recommendations from CEPT Task Group 4 and Project Team 1 in response to the most recent Commission mandate.

3.35 We continue to contribute fully to EU discussions in the months to come and at present we believe that our proposals for the UK digital dividend are not in conflict with discussions currently underway in the above fora. In the meantime, in line with the decision set out in the DDR statement, we believe it right to press ahead with the DDR cleared award in the interests of bringing benefits to UK citizens and consumers at the earliest possible date. We discuss our views on the timing of the award in more detail in the following section. We consider the impact of developments in Europe on technical constraints in section 5.

Section 4

Availability and uses of the cleared spectrum

Introduction and summary

4.1 To specify appropriate technical licence conditions and identify an approach to packaging and auction design that promotes competition and efficiency as well as meeting our other statutory duties, we first need to understand the nature of the spectrum available. We also need to identify the potential uses of the spectrum and how those applications would make use of this resource

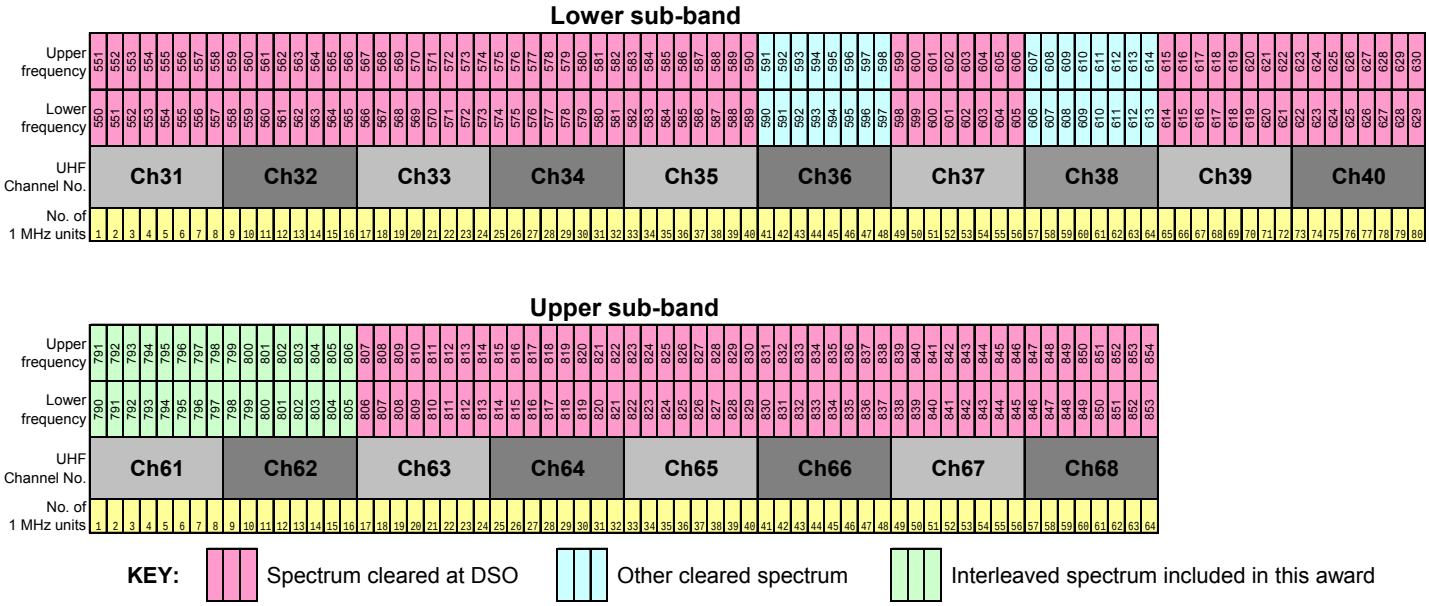
4.2 In this section, therefore, we:

- describe the available spectrum to be awarded;
- describe the constraints that apply to the spectrum;
- discuss the potential uses of this spectrum and how these considerations have affected our approach to this award;
- set out the current timing for this award and, in particular, the implications of further developments at EU level; and
- consider several issues relating to access to this spectrum.

The available spectrum

4.3 As a result of DSO, 112 MHz of spectrum in UHF bands IV and V will be available for new uses on a UK-wide basis. This spectrum corresponds to channels 31-35, 37, 39-40 and 63-68 in the existing plan for this spectrum. Channels 36 and 38 will also be cleared of their current use of aeronautical radar and radio astronomy, and together with interleaved channels 61 and 62 form the entire range of spectrum that will be included in the cleared award. These channels and the associated frequency ranges are highlighted in Figure 4.1 below.

Figure 4.1 The available spectrum



4.4 We recognised at an early stage of the DDR that other channels in UHF bands IV and V had potential to be cleared on a similar timeframe. This spectrum corresponds to channels 36 (currently used for aeronautical radar) and 69 (currently used for PMSE) in the existing plan for this spectrum (also highlighted in Figure 4.1). Channel 38 is mainly used for radio astronomy, and we had no plans to make this available for new uses.

4.5 In the DDR statement, we set out our decision to auction channel 36, which will be cleared of its current use by April 2009, alongside the other cleared spectrum. We also decided that channel 69 should continue to be available for PMSE use throughout the UK on a licensed basis.

4.6 Since the publication of the DDR statement, we have discussed future use of channel 38 with the Department for Innovation, Universities and Skills (DIUS) and the Science and Technology Facilities Council (STFC) - the bodies responsible for radio astronomy in the UK. They have decided to vacate the channel in time for the completion of DSO in 2012. Accordingly, we have decided to include channel 38 in the DDR cleared award. This is covered in more detail later in this section.

4.7 In the DDR statement, we also made a proposal to include the interleaved spectrum in channels 61 and 62 in the DDR cleared award. We discuss this, too, in more detail later in this section.

4.8 In summary, this award will therefore include 128 MHz of spectrum available UK-wide in two blocks of 550-630 MHz (the lower sub-band) and 806-854 MHz (the upper sub-band) as well as 16 MHz of interleaved spectrum between 790-806 MHz – which we now refer to as ‘the DDR cleared spectrum’ and which will be available for new use on a nationwide basis by the end of 2012 at the latest.

Constraints applicable to the available spectrum

4.9 If all the available spectrum were subject to the same domestic and international constraints on its use, there would likely be limited usability differences at different specific frequencies. On this basis, the design of spectrum packages for award by

auction would be relatively simple. However, as initially set out in the consultation on our proposed approach to awarding the digital dividend in December 2006 (the DDR consultation), this spectrum is subject to some significant and variable constraints both domestically and internationally.

4.10 On the domestic side, there is the potential for new uses of the cleared spectrum to interfere with digital terrestrial television (DTT) in the spectrum retained for this service. The main cause of any such interference is most likely to be so-called out-of-band (adjacent- or image-channel) interference. This can result in the existing service being impaired in areas close to a new service's transmitter. To prevent or limit this interference, technical licence conditions may need to be different for channels that are adjacent or near to channels used for existing services. This will constrain the usability, and therefore value, of the spectrum concerned. These issues are discussed in more detail in section 5.

4.11 The protection of existing DTT services from out-of-band interference from new services is an important factor in successfully delivering DSO and in particular making the public service broadcasters' (PSB) DTT multiplexes available on a near-universal basis across the UK covering 98.5% of population. We have therefore considered providing an extra level of protection in the form of a protection clause, which would form part of the set of technical conditions in all new licences. Further details on the protection clause are set out in section 5 and in annex 6.

4.12 On the international side, new services in the cleared spectrum will need to conform to the international obligations agreed at the Regional Radio Conference 2006 (RRC-06) in Geneva. Under the spectrum plan agreed at this conference – known as GE-06 - different channels within the cleared spectrum are subject to different levels of incoming interference from other countries and are also able to generate different levels of outgoing interference to other countries. Therefore, different channels may be more or less suitable for particular new services than others. These issues are also discussed in more detail in section 5. In turn, the specific technical conditions that must be attached to the licences we award will have a large impact on our choice of spectrum packaging. These impacts are discussed in more detail in section 7.

4.13 In the following subsection, we discuss some specific constraints on spectrum availability that apply to certain channels in the DDR cleared award.

Specific availability constraints for certain channels

Channel 36

4.14 Channel 36 is used in the UK for aeronautical radar. In 2007, we gave notice to BAE Systems that we would revoke its licence to use the channel by 31 March 2009. This will mean that channel 36 will be cleared UK-wide well before DSO ends in 2012.

4.15 In the DDR statement, we explained the importance of negotiating international agreements enabling new uses of this spectrum. This is because the UK has no transmission rights in channel 36 under GE-06 for uses other than radar. Rights need to be established on a bilateral basis with the administrations of affected countries to set new mutual interference levels.

4.16 Bilateral agreements are required between the UK and Belgium, France, the Netherlands and the Republic of Ireland. The bilateral process can take time for agreements to be reached as there is no obligation for the affected administration to

agree to coordination requests in any fixed timescale. Administrations are also within their rights to refuse those requests that impact on their own future (perhaps undefined) plans. Nonetheless, discussions have commenced, and we expect to conclude them during the course of this year. In section 5, we consider in more detail the general coordination situation.

4.17 Subject to the successful conclusion of these discussions, we explained in our DDR Statement that we would allow early access to channel 36, which would enable earlier investment in network planning, testing and rollout so that services might be provided earlier than would otherwise be the case. Our modelling work, at the time of the DDR Statement[6], estimated that the magnitude of these benefits could be in the region of £200-500m (net present value over 20 years).

4.18 We also explained that early use of channel 36 could bring with it some potential costs, notably in the shape of harmful interference to Five's analogue terrestrial television service in adjacent channels 35 and 37 in the period before DSO is completed. We therefore decided to allow use of channel 36 as soon as it is available but on the condition that any such use during this period does not materially degrade the reception of Five's analogue terrestrial television service. We believe that this approach will maximise the total value to society generated by using channel 36 and is in accordance with our statutory duties, including securing the optimal use of spectrum and having regard to the different needs of everyone using the spectrum.

4.19 In managing interference from new use of channel 36, we advocate an approach consistent with the protection clause set out in paragraph 5.62 and discussed in detail in section 5.

4.20 In the DDR statement, we ruled out an early award of channel 36. Awarding channel 36 ahead of the rest of the cleared spectrum could involve potentially significant costs but only relatively limited benefits. We explained that the costs could be high as early award could adversely affect the total value to society subsequently generated by using the cleared spectrum as a whole. The benefits of early award were limited as early award was not expected to significantly bring forward the date by which channel 36 could be used. Therefore, our analysis suggested that, on balance, the potential costs could be plausibly higher than the potential benefits of an early award. We present our latest views on the timing of the award later in this section.

4.21 Because channel 36 will have specific international constraints but be available for early UK-wide use, we have had regard to its unique value in determining the structure of packages of licences to be awarded in the auction. Our packaging proposals for channel 36 are set out in section 7.

Channel 38

4.22 UK radio astronomy, centred on the Universities of Manchester and Cambridge, is a world leader in research and facility development. This work dates back to the construction of the University of Manchester's Lovell Telescope Jodrell Bank, and the subsequent development in the MERLIN (Multi-Element, Radio Linked Interferometry Network) array, now the only world-class telescope facility on UK soil. Cambridge hosts the second-largest telescope of the MERLIN array, others being at sites across

[6] These results are discussed in annex 8 to the DDR Statement, and are based on the additional value which may be generated from having access to channel 36 three years earlier than would otherwise be the possible.

the northwest of England.[7] The Science and Technology Facilities Council (STFC) and its predecessors have, since the 1980s, contributed to the operating and development cost of this array, today totalling around £2.3m per annum.

4.23 The array is currently undergoing a major upgrade (e-MERLIN), adding new frequency instruments and fibre-optic links between the telescopes, due for completion in late 2008. STFC also provides funds for the exploitation of the science arising from MERLIN: for UK astronomers to use its telescopes as part of a wider European array (Very Long Baseline Interferometer – VLBI – based in the Netherlands) and as part of a global telescope array. UK astronomers study phenomena at a wide range of frequencies, from 37 MHz to 98 GHz, though in practice focused upon a few key frequencies dictated by science priority. STFC holds Recognised Spectrum Allocations (RSA) from Ofcom, which on payment of an appropriate fee, help ensure UK radioastronomers access to these key frequencies, these include channel 38 (606 – 614 MHz). Several frequencies are shared with other civil and industry users and some enjoy further protection via International Telecommunications Union (ITU) regulations.

4.24 We have had no plans to require radio astronomy use of channel 38 to cease. However, the UK is now looking to develop new facilities for radio astronomy. The most important of these is a proposed global radio telescope facility – the Square Kilometre Array (SKA) – which would probably be sited in a radio-quiet area of South Africa or Western Australia and could be operational from 2014. The consequence of this is that SFTC's investment in radio-frequency protection will focus on the UK's role in the SKA. At the same time, in line with our policy on public-sector holdings of spectrum and the aim of incentivising efficient use by reflecting the opportunity cost of this spectrum, Administered Incentive Pricing (AIP) will be phased in and payable for the continued use of channel 38 by radio astronomy.

4.25 The above developments raised the prospect that radio astronomy use of channel 38 could cease voluntarily more quickly than would previously have been the case.

4.26 In subsequent discussions, the Department for Innovation, Universities and Skills (DIUS) and HM Treasury have agreed terms under which radio astronomy use of channel 38 will cease during 2012. The results of this agreement could mean that UK Science will realise a considerable financial benefit, as a result of placing channel 38 in the DDR cleared auction. DIUS will invite STFC to submit a proposal for investing some or all of this financial benefit in the future of UK radio astronomy.

4.27 Accordingly, we have developed our packaging and auction-design proposals for this consultation on the basis that a licence for the use of channel 38 will be included in the DDR cleared award. This licence will need to have specific conditions that:

- sustain the protection of radio astronomy in channel 38 in the UK until 2012; and
- sustain the protection of radio astronomy in channel 38 in neighbouring countries, which is required under the existing international framework and confirmed at WRC-07, for as long as such protection is required.

4.28 In practical terms, this will limit the use of the channel itself to very low-power applications in much of Great Britain while the protection required for radio astronomy in neighbouring countries persists. However, clearing the channel in the UK will significantly enhance the usability of the adjacent channels 37 and 39 by

[7] MERLIN/VLBI National Facility.

higher-power transmission networks and hence increase the total value to society likely to be generated by using the cleared spectrum.

4.29 In addition, should radio astronomy-protection requirements in neighbouring countries change in the longer term, there may be opportunities for bilateral international coordination to permit less-restricted use of the three channels affected in the UK. However, we do not at this stage envisage that any such longer-term changes will take place in the foreseeable future. We discuss in more detail the technical licence conditions we therefore propose for the licences in the award, on the basis of the above working assumptions, in section 5, and set out our associated packaging proposals for the auction in section 7.

Channel 69

4.30 In the DDR Statement recognised the importance that PMSE users attach to a nationally available channel and decided that use of channel 69 should continue on a licensed basis. We concluded that channel 69 would be included in the rights to be awarded to the band manager

4.31 In our June 2007 consultation on future PMSE access to spectrum (the PMSE consultation),[8] we set out four key objectives to be pursued in designing any future arrangements. These were:

- avoiding disruption to PMSE users that adversely affects their ability to provide a wide range of services to citizens, consumers and business customers;
- facilitating the participation of the PMSE sector in a market-led approach to spectrum;
- promoting the optimal use of spectrum in relation to all potential uses and users over time; and
- avoiding the risks of regulatory and market failure.

4.32 Channel 69 is currently allocated to and used for PMSE, in particular wireless microphones. In the DDR Statement we assessed the status of channel 69 against our objectives for PMSE spectrum access and our broader DDR objective and concluded that channel 69 should be included in the single package of spectrum to be awarded by beauty contest to a band manager who would have obligations to the PMSE community.

4.33 In line with our policy set out in the DDR Statement to transition PMSE use of spectrum to a market based approach the Band Manager will be charged AIP. The rate of AIP payable however will be phased in to reduce disruption to PMSE users.

4.34 We do note however, that channel 69 in isolation is of limited value to PMSE users because touring companies, who generally use channel 69, also require access to channels 67 and 68. Looking ahead, we propose to enter into discussions with the PMSE stakeholders to identify whether there is alternative spectrum, comparable in quality and quantity that could be used in place of channel 69 that may offer a superior long-term solution for PMSE needs.

[8] http://www.ofcom.org.uk/consult/condocs/pmse/pmse.pdf

Channels 61 and 62

4.35 In the DDR statement, we proposed to include the interleaved spectrum available in channels 61 and 62 in the DDR cleared award. This proposal was made in recognition of the international developments described in section 3.

4.36 These suggest that channels 61-69 are increasingly likely to be used for mobile services in other European countries – and possibly on a wider international scale – in the medium term. This, in turn, is more likely to result in mobile-equipment manufacturers producing equipment that can operate over the full range of this sub-band. As technology develops, different mobile data standards beyond the current European UMTS standard for 3G are still being developed, including for Long Term Evolution (LTE) and LTE-Advanced. By 2012, when all the cleared spectrum will be available UK-wide, there may be opportunities for services based on these new standards to start to be deployed at different frequencies, including in the digital dividend.

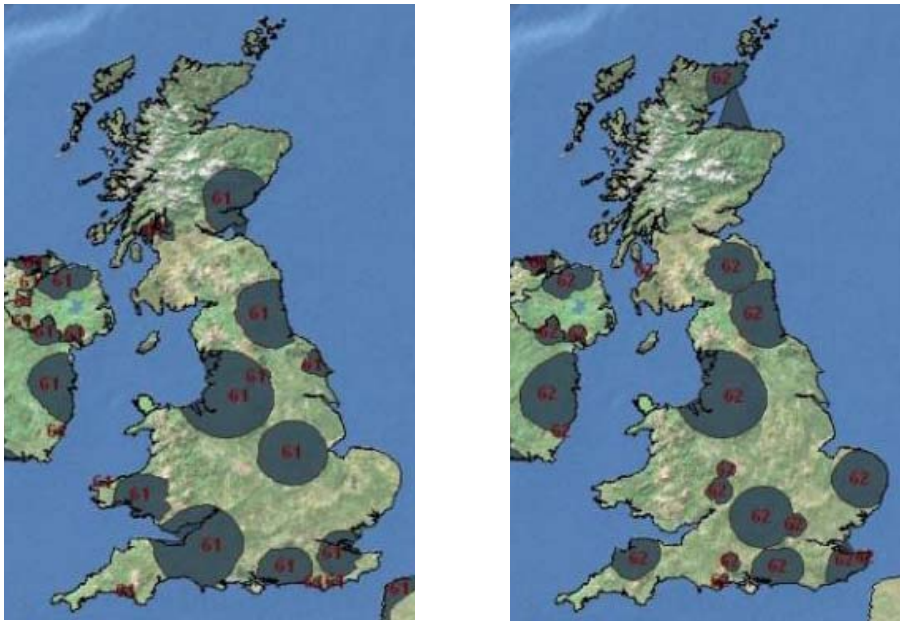
4.37 Mindful of these international developments, we have conducted an initial technical study of the feasibility of operating two-way mobile services in interleaved spectrum, with particular focus on channels 61 and 62, where such services might start to operate in other parts of Europe in the medium term. The study concluded that, while the interference environment for operating mobile services in these channels would be challenging given the need to coordinate fixed transmissions with existing DTT services at various locations, the interleaved spectrum could still potentially offer useful value for such services. It is perhaps unlikely that they would be attractive in isolation and are more likely to form a useful addition to cleared spectrum, enhancing its capacity and providing separation between the large and small cell layers.

4.38 The interleaved spectrum in these channels may also be attractive to a bidder interested in creating a sub-UK DTT multiplex in combination with either cleared spectrum or other interleaved spectrum. We therefore propose that this spectrum should be offered at the same time and as part of the same award as the cleared spectrum.

4.39 We consider the technical licence conditions for this interleaved spectrum and the consequent packaging proposals in sections 5 and 7 respectively.

4.40 Figure 4.2 sets out an illustration of the spectrum that will be available for award across the UK for both channels 61 and 61 respectively. The dark patches represent the areas which will be used by DTT services after the switchover process has completed.

Figure 4.2 Use of Channels 61 and 62 by DTT services post DSO



Channel 61 **Channel 62**

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

Other issues in relation to the availability of cleared spectrum

Cognitive access

4.41 In the DDR statement, we proposed to allow licence-exempt use of the interleaved spectrum by cognitive access subject to verifying that this use will not cause harmful interference to other users.

4.42 However, we did not propose to allow licence-exempt cognitive use of the cleared spectrum. The current development of spectrum-sensing technologies required for cognitive radio is primarily focused on detecting DTT and wireless-microphone signals. The ability of cognitive radio to work in the cleared spectrum is much more uncertain due to the greater uncertainty about the types of service and technology that will be deployed there. As yet, it is unknown whether cognitive technologies would be able to detect and avoid other potential uses of the cleared spectrum. Moreover, as explained in the DDR Statement there may only be a small incremental benefit in allowing cognitive access to the cleared spectrum over and above our proposal to allow cognitive use of the interleaved spectrum. This leads us to believe that the associated costs and risks to licensees of the cleared spectrum might be too high given the size of the possible benefits. If, in the future, cognitive radio is developed that can be used in the cleared spectrum, these could be used by licensees. Alternatively, as licences will be tradable, licensees could permit cognitive access to their spectrum concurrent with their own use. The same considerations apply for the interleaved spectrum in channels 61 and 62. Relative to other interleaved spectrum, there is greater uncertainty as to the future use of these channels. Therefore, we propose not to allow licence-exempt use of channels 61 and 62 by cognitive access.

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

4.43 We intend to publish a consultation document on licence-exempt cognitive access to the remaining interleaved spectrum later this year.

The available spectrum

4.44 In summary, the DDR cleared award will include:

- the 112 MHz of spectrum cleared on a UK-wide basis as a result of DSO;
- 8 MHz of spectrum cleared on a UK-wide basis as a result of aeronautical radar ceasing to use channel 36 in March 2009;
- 8 MHz of spectrum cleared on a UK-wide basis as a result of UK radio astronomy ceasing to use channel 38 in 2012;[9] and
- 16 MHz of interleaved spectrum in channels 61 and 62, where it is not used for DTT.

Uses of the cleared spectrum

4.45 In the DDR statement, we explained that it was the wide range of potential uses of the digital dividend that set it apart from our other spectrum awards. The uses we identified included:

- mobile television and other types of mobile video and multimedia;
- extending existing DTT coverage;
- new DTT channels aimed at a UK market in either standard definition (SD) or high definition (HD);
- new DTT channels aimed at local markets (i.e. local television);
- satellite broadcasting;
- wireless microphones and other PMSE applications;
- other low-power applications, like hubs to distribute content around the home or using ultra-wideband technologies;
- broadband wireless applications, which could be mobile;
- mobile communications, both voice and data;
- services using satellite communications;
- emergency and public-safety services;
- cognitive radio;

[9] International use by radio astronomy will continue in channel 38 up to 2012, which means that some constraints will remain.

- community radio;
- digital radio;
- communication with medical professionals and educational institutions;
- amateur and/or university use;
- new services for people with disabilities;
- international and cross-border uses (e.g. an international emergency channel);
- digital public-service teletext to match the analogue service; and
- user-created networks (e.g. employing mesh technology).

4.46 We also explained that the rapid change in services, technologies and applications in the communications sector means that new uses of the digital dividend will continue to emerge.

4.47 Evidence collected to date suggests some services and technologies are more likely to use the digital dividend than others. In the first phase of the DDR, we conducted two major rounds of market research. We also received evidence from consultation responses, our technical research and economic modelling. Our analysis for the first phase therefore focused most closely on the most likely uses.

4.48 For the cleared spectrum, the most likely uses that we identified were DTT services in SD and HD, mobile broadband (i.e. voice and data) and mobile multimedia services (MMS – including mobile television).

Summary of stakeholder research

4.49 In preparation for the second phase of the DDR, we have undertaken further focused stakeholder research to understand the services that potential users of the spectrum will wish to provide, given that the sector and the technologies it uses are rapidly evolving. Stakeholders continued to identify the following services that they believe are most likely to be offered using the cleared spectrum:

- new DTT channels aimed at a UK market in either SD or HD;
- new DTT channels aimed at local markets (i.e. local television) using the interleaved spectrum;
- mobile television and other types of mobile video and multimedia; and
- mobile broadband applications and other mobile voice and data services.

4.50 This stakeholder research supports our view that we have identified the most likely uses of the cleared spectrum.

4.51 This information is very important to us in deciding what technical licence conditions will be needed to facilitate the coexistence of different types of transmission and receiver network in the cleared spectrum. It is also fundamental to our definition of spectrum packages for the auction. For example, if a likely potential use of the spectrum could only use a technology that required a bandwidth of 6 MHz and our

spectrum packages were set at 5 MHz, this could result in a sub-optimal auction outcome and an inefficient use of spectrum.

4.52 Of course, it is very likely that more potential uses will emerge in future as technology changes and innovators create new products. The benefits of these unknown uses could be as large as, or larger than, the benefits of uses that we can identify now. It may be that these technologies will not fit neatly into the spectrum packages that we propose for this award.

4.53 However, spectrum packages cannot be infinitely flexible. In general, it is true that a larger number of smaller lots offers greater flexibility and can increase the level of competition in the auction. On the other hand, a larger number of smaller lots would increase the risks of interference by multiplying the number of potential boundaries between licensees and would require a more complex auction. Therefore, our choice of spectrum packaging needs to strike a balance between maximising flexibility for the widest range of uses and enabling an efficient and workable auction design to ensure optimal use of the spectrum. We explain how we have sought to strike this balance in section 7.

4.54 Our proposals to make these licences fully tradable should alleviate some residual concerns about our inability to perfectly "future-proof" the licences to be awarded. The spectrum could be traded fully or partially. Partial trades could involve trading geographic or frequency parts of the licence. For example, if a future technology only required a 2.5 MHz bandwidth and a licensed user owned 5 MHz of spectrum, it could trade half of its licensed spectrum to another operator.

4.55 However, we acknowledge the importance of ensuring that the primary award delivers good outcomes and that these, in turn, deliver significant benefit to citizens and consumers in making the right choices. We consider that the time and cost involved in preparing the primary award will be justified by the benefits that it could bring.

4.56 The table below sets out a summary of views that have been provided by stakeholders on the quantity of spectrum they would require for the most likely uses of the DDR spectrum.

Table 4.1 Summary of industry stakeholder engagement findings for the principal potential uses

Service	Likely spectrum requirements per operator
Mobile multimedia	**8- 24 MHz**
DTT SD	**8- 48 MHz**
DTT HD	**8- 48 MHz**
Local TV	**8-16 MHz (at each location in the interleaved)**
Mobile comms	**10- 48 MHz**
PMSE	**Interleaved and 8 MHz (channel 69)**

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

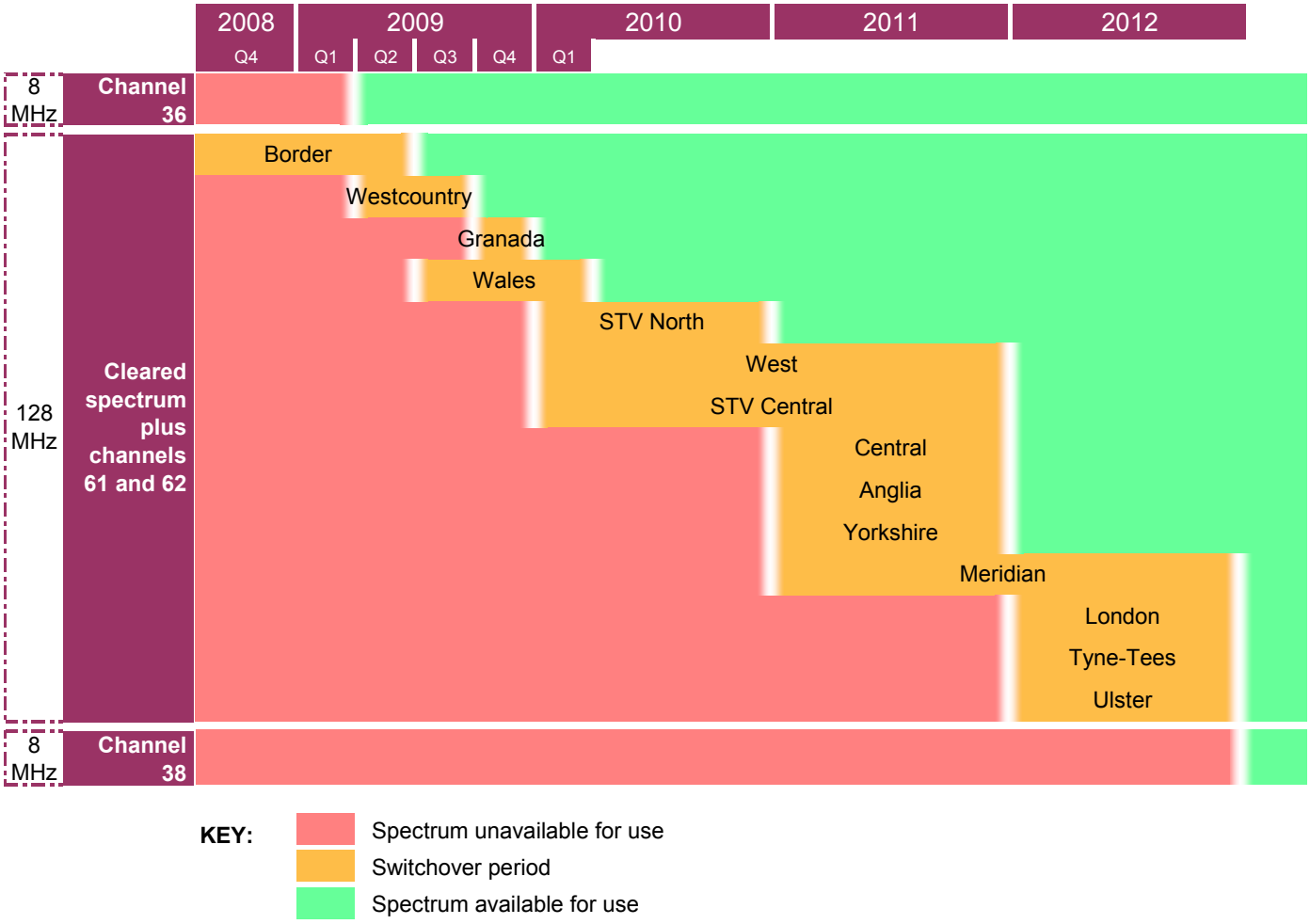
DSO and when the DDR cleared spectrum will be available for new use

4.57 The entire DDR cleared award spectrum will become available for UK-wide use in late 2012. Channel 36 will be available for new use immediately after the award of the DDR spectrum in Summer 2009. At present, we do not believe channel 38 will be cleared of radio astronomy in the UK until the DSO process has been completed in 2012.

4.58 Furthermore, cleared spectrum will become available for use region by region as switchover progresses in accordance with the DSO timetable. The interleaved channels 61 and 62 will be available for new use as per the DSO timetable but co-channel use by DTT will place restrictions in some geographic locations (see Figure 4.2 for more details).

4.59 Figure 4.3 sets out a timeline of when cleared spectrum is expected to become available for use.

Figure 4.3 Timeline for availability of cleared spectrum



Timing of the DDR cleared award

4.60 As set out in the SFR: IP, our starting position on the timing of spectrum awards is to release spectrum that is available via a market led approach and to do so as soon as possible, consistent with an orderly process. This approach allows the market to

decide the best use of the spectrum and ensures that benefits from new services or increased competition flow to citizens and consumers as quickly as possible.

4.61 In the December 2006 consultation document we set out our proposal to award the DDR spectrum as soon as possible. Some stakeholders, notably the existing MNOs, argued that we should delay the release of the DDR spectrum until a number of uncertainties had been removed or reduced. In particular they pointed to the potential for a plan by the European Commission to harmonise some or all of the digital dividend across Member States. Other stakeholders, such as those interested in providing services such as DTT or mobile TV, pressed for an early award of some or all of the cleared spectrum.

4.62 In the DDR Statement, we said that the auction of the cleared spectrum might take place in the first half of 2009. We also reiterated our preference to award the spectrum as soon as possible as this would allow citizens and consumers to receive new services with minimum delay.

4.63 The chart above sets out when the spectrum will become available for use following DSO across the UK region by region. We continue to consider that the award of the cleared spectrum should take place as soon as possible, consistent with the proposals in this document. We consider that the auction could begin in summer 2009. This allows for the likelihood that a second, more detailed consultation will be needed before the end of 2008, focussed on technical and engineering issues that may arise.

4.64 We consider that this timing will give the market the maximum possible opportunity to make use of the spectrum as soon as possible. It will also mean that providers can begin to offer new services with the minimum delay following the cessation of existing uses. This should help to maximise the benefits to citizens and consumers from potential extra competition and innovation.

4.65 We do not think it is likely to be desirable to delay the award of this spectrum artificially beyond this date. We judge that the market is better placed than the regulator to decide the use of spectrum, and that an auction to this timescale would offer a fair opportunity for participation by the wide range of potential bidders. These parties would be able to take into account in their decisions all the information available to them at the time; and the award design proposed here would help to ensure that these decisions were efficiently reflected in the auction outcome.

4.66 We will however continue to take into account developments at EU level in taking decisions on the timing and other aspects of the award. This is in particular because of the scope for European legislative action which could have a binding effect on the UK. This issue is discussed further below.

Developments at the EU level

4.67 As set out in paragraph 3.30 the Commission's communication proposed a common approach to the digital dividend and recommended identifying common bands that could be optimised by enabling 'clusters' of services.

4.68 The Communication concludes its Communication by indicating that the Commission will prepare the required measures to reserve and coordinate the common bands at EU level. Such initiatives are likely to have a bearing on the future use and value of the digital dividend in the UK. Moreover, our award of the digital dividend and the future use of this spectrum will need to comply with any mandatory EU measures.

4.69 Following publication of the Commission Communication in November 2007, discussion of the digital dividend has also moved to the European Parliament and Council. In the Council, a Working Group has focused on the development of 'conclusions' which seek to respond to the points raised in the Communication. It is expected that these conclusions will be adopted at the Telecoms Council which will meet on 12 June, involving the relevant Ministers from the EU Member States.

4.70 In the European Parliament, work on this dossier is being led by the Industry, Research and Energy (ITRE) Committee and Patricia Toia MEP has been appointed Rapporteur for this work. She is producing a report which is expected to be discussed and voted upon in the ITRE Committee in late June and is scheduled to be adopted by the Parliament around September 2008.

4.71 Any future measures proposed by the European Commission are likely to be significantly influenced by the output from the European Parliament and the Council. The UK has actively engaged in these fora, especially in Council where UK Representation has been led by the Government. In both Council and Parliament, the UK has argued strongly that outputs should emphasise:

- The need for rapid resolution to discussions at European level, thereby providing certainty for Member States and enabling them to make the spectrum available in a timely manner for the benefit of European citizens and consumers;

- The importance of adhering to the requirements of the Geneva-06 (GE-06) Agreement which was agreed at the Regional Radio Conference (RRC) in 2006. This agreement, which is the result of years of effort, forms the basis for digital switchover across 120 countries in Europe, the Middle East and Africa. Any proposed major replan of GE-06 could seriously threaten switchover across Member States;

- Given the restrictions imposed by GE-06, and the significant progress already made towards switchover in many Member States, the UK firmly believes that a non-mandatory and non-exclusive approach to the digital dividend is required. This could encourage and facilitate greater consistency and co-operation over time (e.g. by allowing Member States to opt in to flexible measures based on the principles of technology and service neutrality).

4.72 In addition to the activities described above, in April 2008 the EU's Radio Spectrum Committee (RSC) issued a mandate requesting the European Conference for Post and Telecommunications (CEPT) to undertake technical work in relation to the digital dividend. This work, which focuses on the 790-862 MHz band, is intended to identify common technical conditions, international co-ordination and channelling arrangements. The Mandate indicates the expectation of the RSC that any guidance that emerges from this work would be expected to be non-mandatory and non-exclusive. The Mandate specifies that the results of this work should start to become available in December 2008, though final completion is scheduled for June 2009.

4.73 The Commission has indicated its intention to prepare a road map, identifying a regulatory route for dealing with the digital dividend across Europe. This roadmap will need to take account of the ongoing work in the European Parliament and the Council, as well as the technical work in CEPT, and the Commission has said that it intends to make it available by the end of 2008. We continue to be closely involved with this debate and will monitor any implications of these developments for the DDR cleared award over the coming months.

Conclusions on timing of the DDR cleared award

4.74 Our position remains that we will seek to hold the DDR cleared award as quickly as possible, consistent with holding an award along the lines set out in this document. We consider that this is in the interests of citizens and consumers because of the benefits that should follow, linked to the potential for additional competition and innovation.

4.75 We consider that the timetable should however allow for the likely need for a second, more detailed consultation focussed on technical issues later this year. This points to finalising our statement and draft regulations in early 2009, and beginning the DDR cleared award in summer 2009.

4.76 The table below sets out our current timetable for holding the DDR cleared award.

Table 4.2 Timetable for the DDR cleared award

May 2008	First consultation on detailed award design
Summer 2008	First consultation closes
Late autumn 2008	Second consultation on detailed award design
Winter 2008	Second consultation closes
Late spring 2009	Information memorandum and draft regulations
Summer 2009	Award begins

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

Access to the cleared spectrum

Temporary access for PMSE

4.77 In October 2007, we set out our decision to allow temporary PMSE use of channels 63-68 in the regions where DSO will take place before the end of 2009, up to the point where new users need access to the spectrum.[10] We indicated that we would give six months' notice before ending temporary access to these channels.

4.78 We believe that it may now be possible for us to increase the notice period by another 6 months – hence giving PMSE users a 12 month notice period in total. We may also be able to extend temporary access for PMSE to channels 31-40, with a similar notice period.

4.79 We would envisage exercising this notice after the award has been concluded, if we are requested to do by the licensees successful in the award.

4.80 There are two reasons for considering the case for a longer notice period:

- there is a potential benefit to PMSE users from having greater notice of the need to quit the upper band in particular. This is because it could help PMSE users to phase the process of migration to new frequencies. The pattern of interleaved

[10] www.ofcom.org.uk/consult/condocs/pmse/statement/statement.pdf.

spectrum use may be more complicated for some PMSE users after DSO, with a potential need to purchase equipment beyond just like-for-like replacements to access new frequencies;

- the cost to potential providers of new services in the cleared spectrum may be very low or negligible, as it may be unlikely that they will offer commercial services in the first 12 months after award; this period may instead be used for further developing business plans and/or building physical infrastructure.

4.81 We would be interested in views on this issue.

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

London 2012 Olympic Games and Paralympic Games

4.82 As part of London's bid for the 2012 Games, the Government guaranteed to the International Olympic Committee the allocation of the frequencies required for the organisation of the Games. We published a discussion document in November 2007 seeking views from stakeholders on spectrum requirements for the Games,[11] and responses suggest that demand for wireless microphones and other audio links in London could be sufficiently high as to require access to all available spectrum in UHF bands IV and V, including the entirety of the cleared spectrum.

4.83 In our DDR statement, we explained that there might be a case for the rights to use the spectrum cleared as a consequence of DSO in London only taking effect after the conclusion of the Games (which end in early September 2012), rather than from the conclusion of DSO (expected in spring 2012).

4.84 The UK has an international obligation to ensure that there is sufficient spectrum available for the London Games. We believe that the opportunity cost of deferring the start date for rights to the cleared spectrum in London until after the Olympics is likely to be relatively low (except in relation to channel 36).

4.85 The relatively short period in this case distinguishes the DDR from the 10-40 GHz, L-Band and 2.6 GHz awards, where we and the Government have agreed that no Games-related conditions should be included in the licences being awarded.

4.86 We would welcome stakeholders' views on the options available to us, namely:

- not to defer the start date for rights to use any cleared spectrum in London beyond DSO;

- to defer the start date for rights to use the upper sub-band (only) in London until after the Games end; or

- to defer the start date for rights to use all the cleared spectrum in London (excluding channel 36) until after the Games end (ie channels 31-35, 37-40, 63-68, and interleaved 61-62).

[11] http://www.ofcom.org.uk/consult/condocs/spectrum2012/summary/

4.87 We plan to consult on a draft spectrum plan for the London Games after the Beijing 2008 Olympic Games and Paralympic Games.

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

Conclusions

4.88 In this section, we have set out:

- our decision to include channel 38 in the DDR cleared award;
- our proposal to include the interleaved spectrum in channels 61 and 62 in the DDR cleared award;
- our proposal not to allow licence-exempt use of channels 61 and 62 by cognitive devices;
- our assessment of the most likely uses of the cleared spectrum;
- our proposal to award the cleared spectrum as soon as possible, consistent with an orderly process; and
- our consideration of extending the notice period relating to temporary access to the cleared spectrum for PMSE, and of extending temporary access with a similar notice period to channels 31-40; and
- our consideration of the possibility of using cleared spectrum in London to meet the need for wireless microphones and other audio links at the 2012 Olympic Games and Paralympic Games.

Section 5

Technical licence conditions

5.1 In this section we set out our proposals for the Technical Licence Conditions (TLCs) which should be included in the licences in the DDR cleared award. The key purpose of spectrum management is to control interference between different users. This is achieved by imposing a set of TLCs on each licensee to limit the risk that their transmissions will cause significant levels of interference to their geographic and frequency neighbours.

5.2 TLCs can either be focused around the licensees' transmitters or the neighbours' receivers. Traditionally, TLCs were applied to transmitters, effectively restricting their in-band and out-of-band emissions. These conditions, generally termed transmit masks[12], are simple to understand. It is also relatively easy to assess compliance with this type of TLC, by measuring the in-band and out-of-band power of the licensee's transmitters. Transmit masks allow for a level of flexibility as the spectrum can be used for a range of services or technologies provided the power profile of a licensee's transmitters does not exceed the limits in the TLCs.

5.3 However, transmit masks do not directly control the interference levels experienced by neighbours, as they do not account for transmitter density. The more transmitters of a given power that there are in a given area, the higher the risks of neighbours experiencing significant interference from them. Hence, with this form of TLC, neighbouring licensees will have less information on the interference levels that they can expect from the transmissions concerned.

5.4 An alternative approach involves TLCs centred on controlling the interference experienced by the neighbouring licensees' receivers. These conditions are known as Spectrum Usage Rights (SURs). As in the mask approach, a licensee with SURs has flexibility in terms of spectrum use, in that it can use the spectrum for a service or usage of its choice provided it does not exceed its SURs. However, unlike mask-based TLCs, SURs require the licensee to manage both the power of the transmitters and their density. For the same transmitter power, a denser network will result in higher interference such that a licensee may exceed its SURs. To ensure it remains within its SURs, a licensee therefore has to make a careful judgement of its network roll-out based on a trade-off between transmitter power and deployment density.

5.5 Relative to mask-based TLCs, SURs are more complex to define and compliance assessment is not as straightforward. However, because SURs are specified in terms of the interference experienced by neighbouring licensees, they directly control the neighbours' interference levels. Hence, neighbours have a better idea of the interference to expect under such a TLC.

5.6 Following our initial consultation on SURs[13] and subsequent engagement with stakeholders, we proposed SURs as one of the TLC options in the spectrum award consultations for the 2.6 GHz and L-band awards. Since then, we have published two

[12] The general term 'transmit mask' is used to represent the in-band and out-of-band power profile of a licensee's transmitters. However, in the case where a transmit mask is applied at the edge of a block of spectrum of similar usage, then the specific term 'block-edge mask' (BEM) tends to be used.
[13] http://www.ofcom.org.uk/consult/condocs/sur/

statements on SURs (in December 2007[14] and more recently in May 2008[15]) and awarded SUR licences in the L-band auction.

5.7 This chapter is structured as follows:

- First, we assess the suitability of transmit masks versus SURs for this award;
- We then describe the international coordination requirements for the spectrum in the DDR cleared award;
- Next, we present our proposals on interference management between new licensees within the cleared spectrum and between existing users and new licensees, including proposed SUR type TLCs for the licences for the cleared channels (31 to 40 and 63 to 68) and the interleaved spectrum in channels 61 and 62;
- We also propose a set of propagation models and terrain and clutter databases that could be used to model compliance with these proposed SUR type TLCs;
- Alternative potential TLCs, in terms of transmit masks, are then provided;
- Finally, we give an overview of the proposed TLCs for this award.

Determining suitable type(s) of technical licence conditions for this award

5.8 In the introduction to this section, we described the general advantages and disadvantages of the two broad TLC approaches - transmit masks and SURs. In this sub-section, we assess the suitability of these two alternatives in the specific context of the DDR cleared spectrum award.

5.9 As transmit masks do not account for a licensee's transmitter density, it is difficult to estimate with confidence the interference levels that may be experienced by neighbours for a given set of TLCs. This is not so much of an issue where the expected levels of interference, associated with an expected transmission network type and density, are not problematic and there is a low probability of them changing over time. Such conditions may be met in situations where (due to market pressures or regulatory intervention) licensees share a similar transmission technology and network density with their neighbours and any significant future changes to these configurations are relatively predictable and concurrent.

5.10 Some stakeholders suggested this was likely to be the situation for the spectrum in the 2.6 GHz award. They were reasonably confident that neighbours in the band would deploy similar networks of similar power and density, using specific technologies, such that different licensees' future interference levels could be reasonably anticipated. Accordingly, they did not feel the need for SUR-type TLCs in this award. We took careful account of these views in deciding to adopt a transmit mask approach to TLCs for the 2.6 GHz award.

5.11 However, for the L-band award, there was significant uncertainty among the stakeholders regarding the network deployment density of eventual licensees for this spectrum. Both high power/low density and low power/high density networks were envisaged as potential uses. Hence, we specified TLCs in terms of SURs to give

[14] http://www.ofcom.org.uk/consult/condocs/surfurtherinfo/statement/
[15] http://www.ofcom.org.uk/consult/condocs/surs/statement/sur.pdf

greater certainty on the expected interference levels whatever the specific outcome of the award, and proposed to group licensees with similar SUR types together in adjacent frequencies, with a guard band between the two groups.

5.12 Our stakeholder and market research and responses to the DDR consultation have revealed a wide range of different possible services that could make use of the spectrum available for this award. It is not clear which mixture of specific technologies or services will be deployed in different frequencies, when different deployments will occur, and the extent of any changes to technologies or deployments in the future. Further, we propose to facilitate trading of the awarded spectrum, by awarding technology and service-neutral licences. Accordingly, there is significant uncertainty as to the nature of the transmissions that will arise. Given this degree of uncertainty, our preference is to specify the TLCs for this award in terms of SURs because:

- Licensees with SUR-type TLCs are directly limited in respect of the interference they are permitted to cause to their neighbours and are therefore incentivised to comply with this constraint efficiently by optimising the trade-off between transmitter density and transmitter power. Because of the large and uncertain range of transmission network power and density combinations that could be deployed to use this spectrum, SURs are a better mechanism with which to control interference efficiently and flexibly than a transmit mask approach.

- As SURs are specified in terms of the interference experienced by neighbouring licensees, they provide more certainty to these neighbours over expected interference levels. This enables potential bidders in the auction (and traders in the secondary market) to make a more accurate evaluation of the opportunities to use the spectrum for different purposes. Accordingly, the greater level of certainty over incoming interference that SURs can provide is likely to promote a more efficient allocation outcome from the auction. In addition, SURs make subsequent negotiations between different licensees over the use of guard bands between them a simpler process, as the adjacent licensees concerned have a better awareness of the interference they are permitted to cause and expect from neighbours.

5.13 However, there may be situations, e.g. if the award outcome results in one of the sub-bands in this award being wholly used by the same type of transmission network, where there may be a case for the affected licensees to request changes in the relevant TLCs, in line with the change process that we set out in our 2007 SUR Statement[16]. Such requests could in principle include proposing TLCs using a transmit mask approach. Given the proposed timing of the award relative to when transmissions in licensed spectrum might commence, there may be an opportunity to complete the consideration of any such requests before networks are deployed.

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

International coordination

5.14 Irrespective of the type of TLC used, international co-ordinated rights of transmission will have to be respected by the new licensees. These international coordination requirements, which will have a significant bearing on the value of the cleared spectrum, are discussed below.

[16] See paragraph 5.5 to 5.29 in the 2007 SUR Statement

The general coordination situation

5.15 All UHF broadcast TV assignments are coordinated through a framework of bilateral agreements. Under these agreements, the administrations of the two countries define the levels of interference that can be exported and imported between them, on a channel by channel basis. An underlying principle of these agreements is equitable access, such that one country does not gain improved access rights to spectrum at the expense of another.

5.16 To establish a framework for the switchover from analogue to digital television, the Regional Radio Conference at Geneva in 2006 (RRC-06), covering Europe, Africa, the Middle East and most of Russia, considered the implications on a multilateral basis. This culminated in the Geneva-06 Digital Plan for television ('the GE-06 Plan').

5.17 The GE-06 Plan sets limits on the exported field strength in each of the UHF channels that it covers. If the exported field strength in a channel at an agreed geographic boundary lies below the GE-06 Plan threshold (approximately 23 dBμV/m), formal international agreement to an individual country's exported transmissions is not required. Above this threshold, each country's transmissions on each channel must be agreed with the affected neighbouring administrations.

5.18 In the UK, the multilateral treaty commitments represented in the GE-06 Plan have already established rights for the UK to transmit at field strengths above the threshold where necessary at its existing 110 high power/ high tower broadcasting sites. The initial GE-06 Plan left the rights for over 1000 medium/low power broadcasting sites to be separately negotiated with the affected neighbouring countries on a bilateral basis (those sites far from an international border may not give rise to sufficient exported field strength as to require such international agreement). When these rights are agreed via this bilateral process, they can be included in the GE-06 Plan.

5.19 In this way the GE-06 Plan provides a multilateral and flexible framework with which to sustain each country's obligations to protect their neighbours over time. In the same way as the GE-06 Plan provides the flexibility to accommodate bilaterally-agreed amendments that include additional TV transmitters, transmissions from other services can also be accommodated by the same process. Accordingly, as with TV transmissions, proposed transmissions arising from new uses of the spectrum, where they involve sufficiently different transmission parameters, frequencies and transmitter locations to those initially reflected in the GE-06 Plan, will require the bi-lateral agreement of neighbouring administrations if their field strength exceeds the thresholds (typically defined at points such as the coast of the affected country) set out in the GE-06 Plan. As with broadcasting transmissions, the agreed details can be then be added to the updated multilateral Plan to secure ongoing protection via the international framework.

5.20 For the digital dividend spectrum in the cleared award, the UK already has bilateral coordination agreements with France, Belgium, Holland and the Republic of Ireland, supporting the associated existing GE-06 Plan allocations. On this basis, under the existing GE-06 Plan, the UK has transmission rights sufficient to enable a total of eight DVB-T multiplexes to be deployed in UHF Bands IV and V (assuming a Multi Frequency Network (MFN) deployment) where possible. Six of these multiplexes comprise the three PSB and three COM multiplexes that are currently used for DTT, with the channels concerned comprising the interleaved spectrum that will come available in the UK at DSO. The frequencies which provide capacity for two remaining multiplexes will not be used and constitute the cleared spectrum available for this award.

5.21 The level of protection from incoming interference and the constraints on outgoing transmission field strength afforded by the GE-06 Plan (as amended from time to time) may already be adequate to deploy a range of different transmission networks in different channels in each country. In these circumstances, it is possible to operate services without additional formal protection from the Plan.

5.22 However, if a contemplated transmission network requires additional international protection, and/or is likely to exceed existing agreed exported field strengths, any required changes must be incorporated into the Plan following the agreement of neighbouring administrations affected. These bilateral agreements can take some time to be negotiated as both affected administrations need to be able to consider the impacts on their respective plans for the spectrum concerned.

5.23 In the case of digital switchover, the different administrations are at different stages in finalising their plans. In principle, each administration could wait until all details of each others' proposals had been finalised before agreeing to changes to the GE-06 Plan and then awarding spectrum in their own countries. In practice, as noted above, there are many potential transmission configurations that can already be accommodated within the existing GE-06 Plan (potentially secured by varying the power and locations of transmitters as required). Further, there are opportunities for the affected administrations to finalise agreed changes to the GE-06 Plan after spectrum awards but before DSO is completed. Accordingly, in many cases, delaying spectrum awards for possible future bilaterally-agreed changes to the GE-06 Plan could offer limited consumer and citizen benefits but incur large economic costs in the form of delayed access to new services.

5.24 This is the position in the UK, where the existing GE-06 Plan already offers substantial opportunities to exploit the cleared digital dividend spectrum. We therefore believe that it is not appropriate to seek international coordination agreements for possible new uses of the cleared spectrum on a speculative and uncertain basis prior to any award, although we remain able to participate in international negotiations with other affected administrations to amend the GE-06 Plan as and when this is appropriate.

Cleared channels

5.25 Each of the cleared channels has different allowable levels of exported and imported interference in the existing GE-06 Plan, based primarily on the high-power transmitter sites used for broadcasting and the power and the transmit aerial pattern in each case. A simple graphical representation of the allowable interference envelope for each channel was published as an annex to the DDR Statement[17]. More detailed information for prospective bidders will be supplied for each channel in an information memorandum, once our proposals for the DDR cleared award are finalised.

5.26 Several channels are currently required to support a national DTT multiplex in the UK based on a multi-frequency network (MFN). On this basis, a channel that is used in one area will, in general, also be used in other geographically separated areas where co-channel interference is below acceptable levels. Therefore, when the exported interference levels from each affected transmitter using a given channel are aggregated to assess compliance with the international constraints in the GE-06 Plan, the associated interference envelope should, in general, allow a wide range of new services to operate over a significant proportion of Great Britain. Accordingly, as indicated above, we do not propose to enter into bilateral discussions to modify these

[17] http://www.ofcom.org.uk/consult/condocs/ddr/statement/Mason2.pdf.

existing coordination agreements for any channel prior to the DDR cleared award unless such a request comes from an affected administration as part of their own DSO planning activity.

5.27 After the DDR cleared award in the UK, when the frequency location of different licensees, potentially with different transmission network plans, will be clearer, we will consider requests for modifications to the GE-06 Plan secured via bilateral agreement with affected administrations if appropriate. Any use of the cleared spectrum cannot exceed the interference envelope of the associated GE-06 Plan entries. Transmissions from new locations that differ from the existing Plan entries (for example not from a main broadcasting transmitter site) may still require our neighbours to confirm their consistency with the interference constraints of the existing Plan before they are included in an updated Plan.

5.28 Where contemplated transmissions could exceed the existing interference envelope in the GE-06 Plan, we would also consider requests to negotiate with affected administrations to vary the Plan. However, should we agree to pursue such requests on a case by case basis, we can offer no assurance at this stage as to the possible outcome of such bilateral negotiations to vary the GE-06 Plan.

5.29 Each UHF channel in Band IV and V is 8 MHz wide and this is the current basis of the GE-06 Plan entries. While this is the nominal bandwidth for TV transmissions, it may not be optimal for other transmission networks such as 3G mobile networks, which normally operate in a 5 MHz channel raster in Europe. Therefore, new transmissions on a different raster could straddle an existing 8 MHz channel boundary. The GE-06 Plan allows for non-broadcasting transmissions as long as they do not exceed the power density envelopes of the Plan. Where the power density envelope limits for adjacent channels in the Plan are different, and transmissions straddle an existing channel, the lower of the two values of the power density envelope limits concerned should be used for international coordination purposes.

Northern Ireland

5.30 In comparison to the UK mainland, Northern Ireland has a smaller number of cleared channels that are protected in the GE-06 Plan. On some of the channels in the UK's cleared spectrum, Northern Ireland has no rights to transmit at power levels which would breach the ~23 dBµV/m field strength limit at the boundary between Northern Ireland and the Republic of Ireland. Despite these constraints, it will still be possible for licensees for the frequencies concerned to use them for a range of purposes in Northern Ireland, although they would also need to accept incoming interference within the envelope of the Republic of Ireland's agreed GE-06 Plan limits for the channels concerned.

5.31 We discuss the implications of these constraints for the packaging of spectrum in the auction in the sub-section of section 7 which deals with the geographic coverage of licences. A simple graphical representation of the allowable interference envelope for each channel in Northern Ireland was published in an annex[18] to the DDR Statement.

Crown Dependencies

5.32 For the Crown Dependencies (i.e. Guernsey, the Isle of Man and Jersey), which have just a small number of main transmitter sites (sometimes just one), only one or two

[18] See footnote 17

channels in the cleared spectrum have been coordinated to permit outgoing broadcast levels of transmissions under the GE-06 Plan.

5.33 The remaining channels will have very significant constraints placed upon them in the Plan. This is because, where an international border is nearby (particularly France, in the case of the Channel Islands and the Republic of Ireland in the case of the Isle of Man), there will be little or no reduction in interference over the short distance between the transmitter site and the international border. This will, in turn, limit the range of services that may be deployed in these remaining channels without violating the constraints in the existing GE-06 Plan.

5.34 The implications of these constraints for packaging of the spectrum in the DDR cleared award are explored in more detail in section 7.

Channel 36

5.35 As noted in section 4, the UK has no transmission rights in channel 36 under the GE-06 Plan. Rights need to be established on a bilateral basis with Belgium, France, the Netherlands and the Republic of Ireland to set new mutually acceptable interference levels. Discussions have commenced, and we expect to conclude them during the course of this year and expect to make further information available on this issue ahead of the award.

Channel 38

5.36 The international framework requires the UK to take all practicable steps to protect radio astronomy in this channel in neighbouring administrations, because radio astronomy cannot be undertaken except in an environment of very low incoming interference. This commitment significantly restricts the utilisation of channel 38 in the UK except for low power services.

5.37 The permitted limits of interference that are allowed to be caused at a radio astronomy site are given in an ITU publication, ITU-R RA.769-2, and further details on our proposals for the protection of radio astronomy via licence conditions can be found later in this section.

Channels 61 and 62

5.38 In the UK, as noted above, the GE-06 Plan provides established rights for the UK to transmit from a number of specified high power/high tower sites spread across the country in channels 61 and 62, with any coordination requirements for medium/low power transmissions to be addressed by follow-up bilateral negotiations with affected neighbours. In this respect, the position in relation to international coordination is the same for channels 61 and 62 as it is for the cleared channels in the award.

Managing interference between UK licensees

Summary of proposals

5.39 In awarding licences for the DDR cleared spectrum, appropriate conditions need to be included in the licences to limit the risk of harmful interference between licensees. There are two broad types of interference that need to be addressed on an ongoing basis:

- interference between the different services deployed within the DDR cleared spectrum.

- interference between these services and the existing UK DTT services adjacent to the cleared spectrum (up to channel 30 and in channels 41 to 62), interference between these services and international radio astronomy using channel 38 and interference between these services and PMSE using channel 69. There are also transitional arrangements required before the completion of DSO to protect existing analogue TV in channels 35 and 37 (from new services in channel 36) and UK radio astronomy in channel 38.

5.40 We describe our proposals for managing the two types of ongoing interference, and the need for transitional arrangements, in more detail in the sub-sections below. However we first summarise our key proposals.

5.41 To protect new services in the DDR cleared spectrum we propose:

- **Licences with appropriate TLCs.** We will specify licences with appropriate TLCs (SURs or transmit masks) for each of five separate generic types of transmission network, namely DVB-T, MMS, TDD and FDD mobile uplink and downlink. For each generic type of network, the associated licence with its TLC will be one of a number of defined lot categories in the auction for the DDR cleared award, as explained in section 7. In most cases, the TLCs will be the same regardless of the specific frequency of the licence, whether in the middle of a block of similar services, or at the edge of a block of similar services (and therefore potentially neighbouring a different service and transmission network). We term these TLCs to be 'standard TLCs'.

- **Guard bands separating different TLC types.** To address potential interference between neighbouring licensees with different types of TLCs (i.e. those licensees at the edges of blocks of similar licensees in TLC terms), guard bands will be specified before the auction, where no significant transmissions would be permitted. It is important that the size of these guard bands in frequency terms strikes an appropriate balance between mitigating the risk of interference between licensees and utilising the available spectrum efficiently. We therefore welcome stakeholder feedback on the size of the guard bands proposed in this consultation.

- **Guard bands will in general be awarded to the two neighbouring licensees** with the different TLCs concerned, as additional licences with highly restrictive (effectively zero) emission rights in the TLCs concerned. Each of the two neighbours will receive half of the pre-designated guard band. This will enable the two neighbouring parties subsequently to negotiate changes to the TLCs to make use of these guard bands more effectively, and/or to deal with third parties for this purpose, subject to our approval, should they decide this is beneficial. We will however retain the option of not allocating guard bands to new licensees in the event that the auction outcome results in an extremely large guard band, as described in section 8. In such cases we may consider a later and separate award of the guard band where appropriate.

5.42 To protect existing DTT services from interference from the new services entering the DDR cleared spectrum we propose:

- **Additional licence restrictions for all new licensees in the form of a clause for protection of DTT.** We propose existing DTT services will be protected by

including a 'protection clause' in each of the licences for cleared spectrum. This licence obligation will explicitly refer to the detailed coverage/transmission plan of the DTT network after DSO. This will give certainty to the existing DTT broadcasters that planned receivers of their services will receive a defined level of protection, and also give certainty to the new licensees as to the levels of interference they will be permitted to generate. The inclusion of such a clause will avoid the need for large UK-wide guard bands to be placed between fixed transmitters using frequency in the cleared spectrum and the frequencies used by broadcasters in the incumbent DTT network, and the need for overly restrictive emission levels to be specified on a UK-wide basis.

- **Guard bands to separate mobile transmitters from existing DTT.** In addition to the protection clause proposed above, guard bands between any mobile transmission licences and existing DTT channels will be defined. These will address the potential for interference from mobile transmitters that is sporadic and hard to identify. This type of interference might arise from mobile transmissions, the nature of which cannot be controlled by licensees on a day to day basis (such as mobile UMTS handsets).

- **To protect international radio astronomy services in channel 38, we propose that the UK licences for frequencies in channels 37, 38 and 39 will contain an extra condition in addition to the standard TLCs**. We expect the requirement to protect international radio astronomy to cause significant effective constraints to the use of channel 38 and some constraints on the use of channels 37 and 39. These constraints will have a material effect on the relative values of the licences concerned, as discussed in section 7. This licence condition may be altered in future in the event that existing international obligations to protect international radio astronomy services are eased or lifted. We propose no guard bands between the licensee of channel 38 and neighbouring licensees; instead, to mitigate the risk of harmful interference from the (effectively restricted) channel 38 into adjacent channels, we will place a coordination requirement on the licensee of channel 38. Bilateral agreements with neighbouring administrations to ensure protection of channel 38 in the UK from future incoming levels of interference will be necessary.

5.43 To protect existing users in the transitional period before the completion of DSO we propose:

- **For analogue transmissions in channels 35 and 37, to extend the provisions of the DTT protection clause** described above until the completion of DSO. This would protect Five's analogue TV services in channels 35 and 37 from, for example, the use of channel 36 prior to DSO.

- **We propose an extra condition in the licences awarded that use frequencies in channels 37, 38 and 39 to protect the use of channel 38 by the UK Radio Astronomy Service** until the completion of DSO. The TLCs for these licences will be the same as those proposed for other channels of the DDR cleared award.

Managing interference between services deployed in the DDR cleared spectrum

5.44 Neighbouring services deployed in the cleared spectrum have the potential to cause detrimental interference to one another without appropriate TLCs. There are two cases that must be considered which are discussed below:

i) Interference between licensees of adjacent frequencies transmitting with similar networks e.g. two neighbouring FDD downlink licensees. Licensees planning to deploy similar transmission networks are likely (but not pre-determined) to be grouped in contiguous frequency clusters as a result of the award process, as described in section 8.

ii) Interference between licensees of adjacent frequencies who will be transmitting with different types of network, e.g. an FDD downlink licensee that is occupying frequencies adjacent to those used by a licensee for a TDD network.

Interference between licensees with the same licence type in the cleared spectrum

5.45 Based on our stakeholder and market research, the most likely uses for the cleared spectrum are mobile broadband applications and other two-way mobile voice and data communications services, DTT and mobile multimedia services (MMS).

5.46 In order to reduce adjacency risks, given the diversity of potential uses/technologies, we believe it is sensible to tailor the TLCs to the broad transmission network types that are likely to be deployed by the different providers of the expected services, rather than using a complete 'one size fits all' approach to TLCs. A 'one size fits all' approach would have been suitable if the expected services were of similar nature in terms of interference levels generated and transmission network deployment (e.g. all 'high power/high tower'). While the SUR type of TLC allows the licensee to optimise the details transmission network deployment efficiently (e.g. to meet varying geographic conditions within a national network and adjust to technological changes), a "one size fits all" approach would inevitably fail to reflect accurately the very different power characteristics of the general types of network which might be deployed in the DDR cleared spectrum.

5.47 We therefore propose that TLCs (whether based on our proposed SURs or on the alternative transmit mask type) are based on the general transmission technologies listed below. This does not imply that the licences will restrict the use of the spectrum concerned to these technologies or to any particular applications, provided the SURs or transmit masks stated in the licence TLCs are not exceeded:

- Digital Terrestrial Television broadcast transmissions: DVB-T
- Mobile multimedia broadcast transmissions: DVB-H
- Wireless broadband two-way transmissions:
    - IMT FDD (distinguished between downlink and uplink TLCs); and
    - WiMAX operating using TDD, with a single set of TLCs.

5.48 With the exception of TDD licences, we do not propose guard bands between different licensees with the same generic type of TLC, as we assume that the TLCs themselves, whether in the form of SURs or transmit masks, will be sufficient to allow deployments of broadly similar networks to co-exist in adjacent frequencies.

5.49 However, we do propose a 5 MHz guard band separating different TDD licensees. This reflects both stakeholder research and our analysis of requirements. We propose that this guard band is used alongside TLCs which specify reduced out-of-band emission levels to prevent base station to base station interference. This was

the same approach that we took in relation to our 2.6GHz spectrum award[19], the underpinning analysis is discussed further in Annex 7.

5.50 The standard TLCs proposed for each of the above five general transmission technologies are given in Tables 5.1 to 5.5 below. These are expressed in our proposed SUR format for the award. (As noted above, it is possible that, even if licenses are awarded with SUR type TLCs, some licensees may wish subsequently to substitute these with TLCs of the transmit mask type. For information, alternative TLCs expressed in terms of transmit masks are provided later in this section.)

5.51 The SURs in Tables 5.1 to 5.5 have been derived by our technical advisors, Transfinite, based on typical network deployments of the relevant technologies at other frequencies, but adjusted to reflect the frequencies being awarded in this case. The underlying assumptions and system parameters used in deriving these proposed TLCs are given in the consultants' report[20].

5.52 TLCs in SUR format are expressed as in-band and out-of-band power flux density (PFD) limits, defined at specific heights and for a percentage of locations in a specified area. Additional background on basis of the general format used for our proposed SURs is provided in our 2007 SUR Statement.

5.53 Under this format, the in-band limit protects a victim receiver from interference received out of its band of operation, caused by in-band emissions of the transmitting licensee. The out-of-band limit controls interference received in-band by the victim's receiver, arising from out-of-band emissions by the transmitting licensee. The limits are expressed as values which should not be exceeded at more than 95% of locations (or test points[21]) in a defined test area[22] at defined heights with specified frequency offsets. Further details on the heights and frequency offsets relevant to the PFD limits proposed in Tables 5.1 to 5.5 are given in Annex 10.

Table 5.1: Standard SUR for DVB-T

	PFD at 1.5m [dBW/m^2/MHz]	PFD at 10m [dBW/m^2/MHz]
In-band PFD	- 81	- 65
Out-of-band PFD at the centre of adjacent channel	-141	- 125

Table 5.2: Standard SUR for MMS

	PFD at 1.5m [dBW/m^2/MHz]	PFD at 10m [dBW/m^2/MHz]
In-band PFD	- 54	- 38
Out-of-band PFD at the centre	- 114	- 98

[19] See http://www.ofcom.org.uk/consult/condocs/2ghzrules/statementim/statement/statement.pdf
[20] http://www.ofcom.org.uk/consult/condocs/clearedaward/transfinite.pdf
[21] Test points are smaller locations within a test area. Their size will be set out in the licence and will typically depend on factors such as the resolution of the underlying mapping data. For example, a typical size for a test point can be 50m by 50m. In any test area, there may be hundreds or thousands of test points.
[22] The test area is an area covering at least 10 transmitters. Its size is determined based on how large it needs to be in any given location in order to enclose at least 10 transmitters, as set out in the SUR Statement. Generally, it can be expected to cover many square kilometres.

of adjacent channel		

Table 5.3: Standard SUR for FDD downlink

	PFD at 1.5m [dBW/m^2/MHz]	PFD at 10m [dBW/m^2/MHz]
In-band PFD	- 60	- 42
Out-of-band PFD at 5 MHz offset from centre frequency	- 106	- 88

Table 5.4: Standard SUR for FDD uplink

	PFD at 1.5m [dBW/m^2/MHz]	PFD at 10m [dBW/m^2/MHz]
In-band PFD	- 81	- 63
Out-of-band PFD at 5 MHz offset from centre frequency	- 112	- 94

Table 5.5: Standard SUR for TDD

	PFD at 1.5m [dBW/m^2/MHz]	PFD at 10m [dBW/m^2/MHz]
In-band PFD	- 59	- 41
Out-of-band PFD at 5 MHz offset from centre frequency	- 102	- 84

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

Interference between licensees with different licence types in the cleared spectrum

5.54 In most cases, we propose that the standard TLCs set out above are used even if the licensees in neighbouring frequencies have licences with different types of TLC. This is because we propose that interference between frequency neighbours with different TLC types is instead controlled by specifying appropriate guard bands between them, the size of which will depend on the nature of the neighbours concerned. In general, licences with TLCs corresponding to these guard bands are proposed to be awarded to the two neighbouring licensees as an outcome of the auction process, enabling the parties to negotiate their use following the spectrum award should they so wish.

Determining the appropriate size of guard bands

5.55 The selection of appropriate guard band sizes requires a balance to be struck between limiting the risk of harmful interference between neighbouring licensees and unnecessarily sterilising spectrum by specifying a guard band that is too large, which might mean that spectrum lies unused. This could arise immediately or in later years, as technologies improve and services become more robust to interference over time. To achieve this balance, we therefore propose a two-stage approach to the determination of guard band sizes:

- In defining the guard bands to be used in the award process, we will make a reasoned judgement of the appropriate guard band sizes, based on appropriate technical interference studies and consultation with stakeholders.

- Following the spectrum award, neighbouring licensees will be able to negotiate with each other if appropriate to modify the emission restrictions contained in the guard bands awarded to them. Thus, for example, if the judgements made at the time of the award subsequently transpire to be overly-cautious for the specific requirements of the neighbours concerned, the affected neighbours can agree appropriate TLC changes for the licences concerned, following the process set out in the 2007 SUR Statement.

- The sizes of the guard bands that we propose to use for the award are set out in Table 5.6 below for the possible combinations of neighbouring TLC types. To identify these proposed sizes, we have undertaken work to investigate the interference between the likely different services which will be deployed in the DDR cleared spectrum. Further details of this work and the assumptions that have been used in deriving these values are provided in Annex 7.

5.56 Given the many possible uses of the DDR spectrum, we cannot know in advance many of the technical details regarding the networks which could be rolled out for different services. We would therefore welcome comments on these proposals before the various TLC parameters are finalised for the award. Where stakeholders consider that the proposed guard bands should be of different sizes, we request that respondents to the consultation supply appropriate information and/or evidence to support their proposals for more appropriate guard bands.

Table 5.6: Proposed guard bands between different TLC types in the cleared spectrum

Adjacencies	Guard bands (MHz)
Like services	0[23]
DVB-T – MMS	5
DVB-T - FDD downlink	5
DVB-T - FDD uplink	16
DVB-T – TDD	16
MMS - FDD downlink	5
MMS - FDD uplink	19
MMS – TDD	19
FDD downlink – TDD	5
FDD downlink – FDD uplink	10
FDD uplink – TDD	5

5.57 As indicated in paragraph 5.49 above, we also propose a 5 MHz guard band for adjacent TDD licensees. We also propose this for neighbouring TDD and FDD licensees. We propose that this guard band is coupled with adapted TLCs which specify reduced out-of-band emission levels, in order to prevent harmful base station

[23] However, a guard band of 5 MHz is proposed between adjacent TDD operators.

to base station interference. This approach was used in the 2.6GHz spectrum award[24]. This is discussed further in Annex 7.

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

Managing interference between new and existing users

5.58 There are five sets of existing users of adjacent spectrum who we consider could be affected by harmful interference from transmissions by new licensees in the cleared spectrum following the proposed award:

- Existing DTT transmitters, including those in channels 61 and 62, where the affected channels may extend beyond those immediately adjacent to the cleared channels, and include the next-but-one adjacencies ('n+2') and the image channel adjacencies ('n+9').
- The international radio astronomy services in channel 38, whose protection is expected to continue outside of the UK after the completion of DSO;
- UK radio astronomy users in channel 38 up to the completion of DSO;
- PMSE users in channel 69, and
- Channel Five's analogue broadcasts, which are expected to continue in channels 35 and 37 until DSO.

5.59 There are several generic types of mechanism that could be used to protect these different existing users from harmful interference including:

i) **Frequency-based guard bands** separating the new licensees from the adjacent existing licensees. Since the new licences are proposed to be UK-wide, the required guard bands would also need to be UK-wide.

ii) **Geographic exclusion zones** could be put in place, within which new transmissions would be restricted or prohibited. Where the receivers requiring protection are geographically dispersed (as in the DTT network for example), and the details of the new transmission networks are unknown, such an approach would require conservative assumptions to be made to prevent interference, resulting in large geographic areas of the UK being unavailable for transmissions.

iii) **General protection obligation**, which would take the form of a condition in the new licences requiring the licensees to plan their networks so as to avoid harmful interference with a designated set of existing transmissions, as received by a designated set of receivers, and to undertake specified remedial action if this specified level of protection was nevertheless infringed. This method may allow neighbouring existing and new licensees to coordinate their usage more closely in frequency and geographic terms.

5.60 The appropriate measures to employ will depend on the nature of both the existing and the new services. For example if the existing users employ a nationwide, fixed transmission network (as in the case of DTT), different protection measures are likely to be appropriate to those which are relevant for users which are mobile, where the

[24] See http://www.ofcom.org.uk/consult/condocs/2ghzrules/statementim/statement/statement.pdf

locations of transmissions change over short timescales (as in the case of PMSE). Similarly in the case of new services, different approaches are likely to be appropriate to deal with interference arising from new fixed transmission networks versus transmissions from mobile handsets. Equally the existing users could, without careful consideration, cause interference to the new services occupying the cleared spectrum, and the protection measures adopted should also reflect this consideration.

5.61 We discuss managing interference for each of the above five cases of existing use in further detail in the following paragraphs.

Protection of existing DTT

5.62 The six DTT multiplexes are broadcast from a fixed network of transmitters across the UK. Three of these multiplexes (the public service multiplexes) carry public service content (such as the BBC and ITV1 services) and are broadcast from 80 main medium to high power transmission sites and over 1,000 low to medium power relay sites. These multiplexes are required by their Broadcasting Act licences (or, in the case of one BBC multiplex, its Royal Charter) to match the coverage of the existing analogue terrestrial network.

5.63 Ofcom research has concluded that this covers 98.5% of UK households for roof-top reception. The UK's digital switchover plan (as prepared by the Joint Planning Project – JPP) has therefore allocated suitable frequency assignments (based upon the outcome of the Geneva 06 conference – GE06) to these multiplexes to enable them to match this coverage post switchover.

5.64 The three remaining multiplexes are operated on a commercial basis and do not therefore have any specific coverage obligations in their licences beyond the requirement not to reduce their existing coverage at switchover. The UK Planning Model (UKPM) predicts that the six multiplexes currently cover around 73% of UK households from 80 transmission sites.

5.65 The commercial multiplex operators have indicated to Ofcom that they do not intend to adopt additional sites at switchover but that they will adopt the maximum power possible at these sites at switchover. The JPP has optimised the UK switchover plan to implement this and it is currently expected that they will collectively cover just over 90% of UK households following switchover.

5.66 It is possible that any new services that are deployed in the cleared spectrum close to the channels used for these post-DSO DTT transmissions could interfere with the (then) existing DTT reception. In some cases, this interference may be sufficient to prevent the reception of DTT signals in areas where they are planned to occur.

5.67 In principle, interference to these planned DTT signals from new services using the cleared spectrum could arise in two ways:

i) Through out-of-band emissions from the new services entering the TV receivers in their own band of operation. In practice such interference will be regulated by the out-of-band emission restrictions in the new licence TLCs as discussed above (using either the SUR or transmit mask approach to TLCs); or

ii) Through the in-band emissions of the new services entering TV receivers. In practice such interference will be regulated by the in-band emission restrictions in

the new licence TLCs as discussed above (using either the SUR or transmit mask approach to TLCs).

5.68 While these TLCs, coupled with appropriate guard bands where needed, can therefore typically reduce the risks of harmful levels to acceptable levels, the specification of the exact constraints still requires a judgement to be made over the appropriate level of remaining risk to neighbouring users that different parameters would imply, as discussed above. For existing DTT reception, we consider that, in light of the coverage obligations imposed on the relevant providers, it is appropriate to consider a high level of protection for users of existing PSB DTT services to ensure this risk is reduced to appropriately low levels as efficiently as possible.

5.69 We also think that it is appropriate to consider a high level of protection for post switchover commercial DTT services. This is because the commercial multiplex operators will be working to an assumed level of coverage as envisaged in the current switchover plan. That is, the operators will be planning on the basis that their services will cover 90% of UK viewers at switchover, this being based upon their acceptance of licence variations to implement switchover and the allocation of new frequency assignments from their existing sites.

5.70 We also note that viewers in these areas are being advised[25] that these (commercial) services will be available to them at switchover which we consider should be taken into account when determining the appropriate level of protection of these services.

5.71 There is therefore a case for providing additional protection to the reception of DTT services, while taking into account also the effect of this on new services that might be deployed.

5.72 Moreover, a specific design aspect of the DTT receivers that are currently in use means they can be susceptible to interference not just from transmissions in immediately adjacent frequencies (as is typical), but also from transmissions at much wider frequency separations (including the 'n+9' image channel, as noted above). This particular aspect needs to be taken into account in protecting DTT reception.

5.73 In paragraph 5.59, we outlined three possible generic approaches that could be adopted to protect existing uses of the spectrum (in conjunction with pre-set national emission restrictions in TLCs): guard bands, geographic exclusion zones or a general protection obligation.

5.74 While guard bands and/or other extra emission restrictions in the licences where transmissions at frequencies close to DTT channels are likely to occur could in theory offer the required level of protection, the restrictions required would in practice have to cover a large amount of frequency and geographic area. This approach would therefore not be spectrally efficient as it would significantly reduce the amount of usable spectrum that could be awarded in the cleared channels. Furthermore, even very wide guard bands of this nature would not deal with the potential problem of interference via the 'n+9' image channel, where services further away in frequency from the existing broadcast network may still cause interference. Therefore, we do

[25] Viewers are being advised by Digital UK (DUK), a body set up and funded by broadcasters, using a post code database which advises them what services they can expect to receive at switchover. This information is based upon the results from the UKPM, which addresses assignments to and use of spectrum by commercial multiplex operators as well as PSB multiplex operators and the current understanding of international interference

not believe a guard band approach would fulfil our relevant duties in the most effective manner.

5.75 Geographic exclusion zones are likely to be required in substantial proportions of the country for those new transmissions in cleared channels that are closest in frequency to the affected existing DTT channels. Furthermore, to ensure protection from interference via the image channel, it also may be necessary to add in smaller exclusion zones further away from the DTT frequencies. It is difficult for us to determine the appropriate geographic exclusion zones that might be required in the absence of detailed knowledge of the new transmission networks which could be deployed. Under such an approach we would therefore probably need to make conservative assumptions, resulting in larger exclusion zones being imposed on the new licensees than may be required in practice. Although this might safeguard the existing DTT network from harmful interference, the large areas that would be affected by the exclusion zones would imply a significant reduction in the value of the cleared spectrum. We therefore do not believe that such a general approach would be the most effective means by which we can fulfil our relevant duties.

5.76 Instead, the proposed protection clause appears to us an effective way of balancing our duties. This proposed licence obligation would first require the new licensees to plan their networks to avoid harmful interference, in light of a pre-defined post DSO DTT coverage plan, but also if such interference was nevertheless caused, to remedy any disruption to DTT reception. The advantages of this approach would be:

- For the broadcasters using the existing multiplexes it offers protection of the expected post-DSO DTT reception from the transmissions of all new licensees – ranging from their nearest frequency neighbours to those neighbours who may interfere via the image channel. If interference is caused, it places the obligation to remedy the interference, in an appropriate but flexible manner, on those creating the interference in the first place.

- For the new licensees in the cleared spectrum it enables them to plan and deploy their transmission networks efficiently, where appropriate utilising the radio spectrum close to DTT in frequency and geographic terms. As the DTT network, and the coverage it provides, are pre-defined and the transmitters are fixed, it is possible to provide a clearly defined plan against which new transmission interference can be controlled. This offers new licensees much greater certainty in knowing what they must protect before they deploy networks. If interference is nevertheless caused to DTT reception after transmissions commence, then the licensees have the choice of adjusting their transmissions to restore the situation (for example by altering their power or location) or remedying the reception of those affected (for example by installing superior reception filters to affected receivers).

5.77 As noted above, the existing DTT channels which may be affected are not confined to those which are immediately adjacent to the cleared spectrum channels (n+1) or the next but one adjacencies (n+2). Other existing DTT channels would potentially be affected due to the existing DTT receivers in operation having particularly poor selectivity of the image channel. In fact, every channel in the cleared spectrum is either immediately adjacent (n±1) or is at the image channel (n+9), to one of the existing DTT channels, and in some cases both. The case for including a protection clause in the licences for interleaved channels 61 and 62 is even more important, given that new services will co-exist with DTT transmissions in these channels. Therefore, we propose that every licence in the DDR cleared award will include the protection clause.

5.78 A licensee could potentially comply with his obligation, and ensure that his transmission network deployments did not cause interference, either by geographic isolation of its transmissions from those areas where DTT reception occurred in neighbouring spectrum bands, or by careful planning of the direction of transmission antennas. Correcting any subsequent interference that did arise could then be achieved by either:

i) Changing the transmissions (e.g. by reducing the transmit power or aligning the antenna) so that the affected DTT receiver(s) will now work; or

ii) Upgrading the DTT receiving system (e.g. with a superior receive filter) so that the interference is no longer problematic.

5.79 There might be benefit in the level of protection created by the licence obligation changing over time. For example, the protection offered to receivers purchased after a particular future date could be reduced, or removed. This could incentivise manufacturers to enhance the performance of future generations of DTT receivers. Indeed, the scope of protection to existing receivers could itself be time-limited (e.g. to a period defined by the continued correspondence of future DTT transmissions and hence coverage areas to those in the pre-defined plan, and/or by a long stop date aligned to the expected lives of existing receivers). Conversely however, any such changes to the level of protection would however also need to take into account the additional protection that DTT might require as a result of change of multiplex technology to DVB-T2.

5.80 In summary, we propose that the addition of a protection clause to all licences in the cleared spectrum award is the most effective means of ensuring that existing plans for post-DSO DTT reception are not affected by the award and that, subject to this, optimal use of the radio spectrum is made.

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

5.81 The exact formulation, implementation and operation of this clause are important and will require careful consideration. We discuss the proposals at a high level below and consider further details of implementation in Annex 6.

5.82 In outline, we propose the following:

- The output of DTT planning modelling (undertaken by NGW and others) will be made available to new licensees before the cleared spectrum award to enable them to plan the roll-out of new transmission networks so as to avoid interference to DTT.

- Where a licensee does cause interference to defined DTT reception, the licensee will be required to deal with it, whether by changing their transmissions or by upgrading the users' DTT reception system.

- Where possible, the licensee whose transmissions created the harmful interference would bear the costs of investigation and the costs of remedying the problem, which may potentially include a payment to the users of DTT receiving equipment. Such a payment would cover the cost of providing an alternative

means of access to digital television services if the licensee cannot otherwise remedy the interference being caused.

- An appropriate time limit for the resolution of a problem once identified could also be put in place.

5.83 We believe that the best way to progress the finalisation of the licence obligation and to work through its practical implementation is through direct engagement with interested stakeholders.

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

Which DTT signals would be protected?

5.84 The current analogue television transmission network was established on the basis of roof top reception with an aerial at a height of 10 metres. Analogue coverage is currently determined and protected on this basis. At some locations in areas of high field strength it is possible to receive analogue TV signals of adequate quality with indoor/set top aerials although they are not considered to be protected. The UK DSO plan has similarly been established based on roof top reception with an aerial at a height of 10 metres.

5.85 We propose that protection of DTT will be offered to reception via rooftop antennas within a defined coverage area. The protection will be in line with our current interference policy and consistent with our approach under DSO, as well as being the basis of the coverage plans to which we propose to tie the new licensees' obligations. Further work will be required to determine the exact coverage areas which will apply.

5.86 Currently indoor/set top antennas are used by a number of UK households. Approximately 5% of households use such an antenna as their reception mechanism on their primary set and around 45% are used as the reception mechanism on additional sets. Protection of indoor/set top antenna reception is not conferred under our current interference policy or under any decisions that we have made under DSO. It is also difficult to specify set top antenna equipment requirements, making a licence obligation to protect such antennas potentially uncertain or overly burdensome. We propose to undertake further work during the period of this consultation to better understand the implications to consumers and citizens of not protecting indoor/set top antennas and would welcome views from stakeholders on this issue.

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

5.87 We suggest that protection is extended to all reception devices in the home that incorporate a DTT receiver, including TVs and hard disk recorders that have characteristics that comply with the RF requirements of the D Book specification which is developed and maintained by the Digital TV Group (DGT[26]) for DTT

[26] http://www.dtg.org.uk/

reception in the UK. This implies that any mitigation provided would need to include all relevant DTT reception devices. We propose that protection would only apply where these devices are connected to an appropriate external antenna at roof top height.

5.88 The exact DTT transmissions that are protected would need to be defined at the time of the award. They are likely to include those in the relevant DSO plan at the time, including any additional protection that DTT might require as a result of change of multiplex technology to DVB-T2.

Interference from mobile transmissions

5.89 While a general obligation in the form described above is of particular benefit where the new licensee can plan a fixed, compliant, transmission network in advance, it is less effective at dealing with the generally transitory nature of mobile transmissions, where exact transmission densities are not under the day-to-day control of the licensee. These can make the exact diagnosis of particular interference problems difficult (for example those caused by mobile handsets moving past a house). In addition to the protection clause outline above, we therefore propose that further measures are required to protect DTT receivers from mobile transmitters, in the form of a minimum separation between frequencies used for mobile transmissions and those used for existing DTT transmissions.

5.90 The size of the frequency separation required for this purpose has already been the subject of evaluation by the CEPT in considering the requirements for European harmonisation of digital dividend spectrum. The emerging proposal is that substantial frequency separation will be needed. We propose to achieve this level of separation by specifying that a significant 16 MHz guard band would be required between mobile transmitters and neighbouring existing DTT. Work we have undertaken suggests that this would be sufficient to protect fixed rooftop antenna DTT reception from both close adjacent channel interference and also from interference entering via the image channel. A summary of the technical work carried out by our consultants, ERA, underpinning this proposal is presented in Annex 8 and the full report is provided at http://www.ofcom.org.uk/consult/condocs/clearedaward/era.pdf

5.91 This guard band would then define the *minimum* possible frequency separation between mobile transmitters and the existing DTT channels that the award process could allow. However, depending on the other types of use of the spectrum, larger separations could emerge from the auction outcome. It is entirely likely, for example, that even larger separations between the licences for FDD uplink transmissions and those for existing DTT transmissions will emerge as a result of the award process.

5.92 As set out above in section 8, it may be appropriate for us to retain a very large guard band of this kind (i.e. not award it) if the need for one emerged as an auction outcome (as a result of existing DTT and mobile transmission licence types becoming frequency neighbours as the highest-value outcome of the auction). This is because, although no transmissions in the affected frequencies would then be permitted on a UK-wide basis, there may be opportunities for low-power applications to use the spectrum on a geographically-selective basis (given the locations of the protected existing DTT transmitters). It is possible that more efficient spectrum use would emerge if the spectrum concerned was not bundled with UK-wide licence with entirely different FDD or TDD TLCs. The large amount of frequency concerned, effectively with geographically interleaved power restrictions, could instead justify the cost of a separate (contingent) award.

Technical licence conditions for the interleaved spectrum

5.93 As explained in section 4, we propose to award the interleaved spectrum in channels 61 and 62 alongside the cleared channels.

5.94 Services in the interleaved spectrum in channels 61 and 62 would operate on a co-channel basis with existing DTT services. To protect existing DTT services from interference, the protection clause would also be included in the licences for frequencies in the interleaved spectrum in channels 61 and 62. The TLCs for these licences would be the same as the standard TLC of a cleared channel of the relevant service.

5.95 However, as a guard band of 16 MHz is required between existing DTT and mobile uplink transmissions, the proposed packaging and auction rules will preclude the award of licences for FDD uplink or TDD TLCs in both the interleaved spectrum in channels 63 and 64.

Protection of international radio astronomy services

5.96 Within channel 38 (606 to 614 MHz), there is a secondary allocation to the Radio Astronomy Service at 608-614 MHz for observations in a number of European countries, including the UK. There is an enduring international requirement on the UK (and other administrations) to protect radio astronomy sites according to the levels given in ITU-R RA. 769-2.

5.97 As set out in section 4, radio astronomy use of channel 38 in the UK is planned to cease during 2012. Therefore, the requirement to protect the UK radio astronomy sites will only remain until that date, and a licence for channel 38 will be included in the DDR cleared award. However, the requirement to protect radio astronomy sites in neighbouring administrations is expected to continue beyond 2012. For as long as such protection is required, it is likely to mean that only low power services would be capable of using channel 38 in the UK. The same protection requirement will also create some constraints on the UK use of the adjacent channels 37 and 39.

5.98 In this sub-section, we:

- provide more detail on existing radio astronomy sites and the indicative separation distances that will be required between existing sites and new uses; and
- consider the impact of the international protection requirements for the licences in Channels 37, 38 and 39.

5.99 The radio astronomy sites[27] in the UK and those of UK's nearest neighbours are shown in Table 5.7 below:

[27] Further details on the sites can be found at www.craf.eu

Table 5.7: Radio astronomy sites operating in channel 38 in the UK and its closest neighbouring administrations

Radio astronomy sites		Observation modes		
Country	Name	Single dish	Interferometer	VLBI (Very Long Baseline Interferometery)
UK	Jodrell Bank	✓	✓	✓
UK	Cambridge	✓	✓	
Netherlands	Westerbork	✓	✓	✓
Germany	Effelsberg	✓		✓
Belgium	Humain		✓	
France	Nançay	✓		

5.100 Table 5.8 below shows the potential practical impact of the international protection requirements on the notional separation distances that would be needed between European radio astronomy sites and DVB-T/DVB-H[28] and FDD/TDD base stations. These separation distances are provided for information only, and would not form part of the TLCs in licences, e.g. by specifying geographic exclusion zones. We have given separation distances for single dish observation mode as this requires the most stringent protection levels.

Table 5.8: Separation distances[29] between European radio astronomy stations and DVB-T/DVB-H and FDD/TDD BS

	Separation distances for radio astronomy Single Dish Mode (km)	
Channel	DVB-T/DVB-H	FDD/TDD base station[30]
Co-channel (Ch 38)	797 (460)	> 750 (430)
Adjacent channel (Ch 37)	124 (37)	475 (195)
Adjacent channel (Ch 39)	351 (125)	520 (225)

NB: Separation distances shown in parentheses apply when 30 dB of mitigation is used.

5.101 We have undertaken some indicative calculations to determine the emission levels that might not cause interference to the international radio observatories shown above. These show that levels of between 200mW and 10W could be utilised over varying geographic areas of the UK without causing interference to the international observatories. We have also undertaken calculations which indicate the potential

[28] Digital TV standards other than DVB-T/DVB-H are likely to have a similar impact.

[29] The separation distances were derived assuming land path only. If sea path is assumed, which should be the case when the path is over water, the required separation distances will be greater. All separation distances in our analysis of interference into radio astronomy assume land path only. Separation distances in Tables 5.8 and 5.9 are based on a DVB-T/DVB-H transmitter of 1 kW ERP at a height of 150m and a FDD/TDD transmitter of 610 W ERP at a height of 30m. Where appropriate, these transmitter characteristics were used in our analysis.

[30] The FDD/TDD channel bandwidth is assumed to be 5 MHz. The centre frequency is 611 MHz for a base station operating co-channel with the RAS, 603.5 MHz for channel 37 and 616.5 MHz for channel 39

impact of these constraints on the use of channels 37, 38 and 39. Full details of the calculations are presented in Annex 9 but the key findings are summarised below.

Impact on Channel 38

5.102 All four of the international radio astronomy sites are within 400 km of mainland UK. The required separation distances (when considering the radio astronomy site's single dish mode of operation) are in excess of 750 km for both DVB-T/DVB-H and FDD/TDD base stations, and 300 km for user equipment. Accordingly, the international requirement to protect these sites means that the use of channel 38 in the UK would in practice be heavily restricted (most likely to low power applications), especially in the East and South East of England. From the above considerations, we think that lower power services would represent the most likely uses of a channel 38 licence following the completion of DSO and before any easement of the existing international restrictions. Given this, there are two approaches we could adopt to define TLCs for channel 38:

- We could adopt the same set of TLCs as specified for other channels, based upon DTT, MMS and two-way communication services. Although these TLCs allow national high-power services, the obligation to protect international radio astronomy services would in practice restrict the emissions that could occur within the UK while the international protection requirement remained; or

- We could specify a dedicated TLC for channel 38 for low power services, consistent with the restrictions which we think the protection of international radio astronomy are likely to place on UK emissions.

5.103 We propose to adopt the first approach because there is a risk that specifying low power national TLCs could be overly restrictive for particular licensees whilst international protection obligations remain. Furthermore, such TLCs would require revision were deployment of higher power services desired in the event that international protection obligations were changed (e.g. if one of the sites were to close after 2012), potentially adding regulatory uncertainty. In contrast, in the former case, there is little risk of the TLCs being overly restrictive and TLCs may also be appropriate for subsequent high power services in the event of eased international emission restrictions. Because the practical use of the channel will be dominated by the international restrictions, rather than the nature of the TLCs, the potential value of this channel seems unlikely to be materially dependent on the TLCs associated with it. This means that a single lot category may be appropriate for the award of channel 38, regardless of the TLCs that the relevant licensee chooses to select. The impact of this proposal on spectrum packaging for the award is discussed in section 7.

5.104 Given the severe restrictions that must be applied to this channel at the time of the award, we propose that the basis for its award as a lot should be that it does not sterilise any further, more valuable, spectrum in the DDR cleared award. Otherwise the award of this highly restricted channel could prevent valuable neighbouring spectrum from being utilised, for example, in the case where neighbouring channels are required as guard bands separating the protected licensed use of channel 38 from interference from transmissions in other frequencies. In this respect, even transmissions at the low power levels that would be consistent with protection of international radio astronomy in channel 38 could still potentially cause interference to neighbouring UK licensees in channels 37 and 39, particularly if mobile devices were deployed in channel 38.

5.105 We therefore propose to include an additional restriction in the licence for channel 38 to coordinate its use with the UK licensees in channels 37 and 39 (if different). The purpose of this obligation would be to prevent harmful interference to services that could be deployed in neighbouring channels without needing to sterilise spectrum by using guard bands.

5.106 In summary we propose the following technical conditions will apply from the end of DSO to the licence awarded for channel 38:

- Technical licence conditions which are the same as those proposed for other channels of the DDR cleared award, based on the 5 standard TLCs shown in Tables 5.1 to 5.5 above;
- No guard bands separating the licensee of channel 38 from neighbouring spectrum licensees;
- A coordination requirement on the licensee of channel 38 to specify the reasonable terms of usage of channel 38 that are acceptable to each frequency neighbour, to mitigate the risk of interference;
- A requirement to protect the use of channel 38 by international radio astronomy services to the levels given in ITU-R RA. 769-2. (This requirement may be removed in the event that obligations to protect international radio astronomy services are eased or lifted).

5.107 Furthermore, we note that we will also have to establish bilateral agreements with neighbouring administrations to ensure protection of channel 38 in the UK from future incoming levels of interference which could limit the potential of future services in the UK in that channel.

Impact on Channels 37 and 39

5.108 The use of both channel 37 and channel 39 by new DVB-T and DVB-H services will be rendered more feasible after the completion of DSO because channel 38 in the UK will not need to be protected from this time. Similarly the use of channels 37 and 39 for FDD/TDD uplink transmissions in the UK is unlikely to exceed the interference limits at international radio astronomy sites.

5.109 However, without mitigation, the international protection requirements may still restrict national network deployments of FDD or TDD base stations in channels 37 and 39, especially in the East and South East of the UK. This is because the required separation distances would exceed 400km, while the protected radio astronomy sites are within 400km of these parts of England. The required separation distances for channel 37 are significantly less than those for channel 39, due to the 2 MHz gap between the upper boundary of channel 37 and the lower boundary of the Radio Astronomy Service allocation in channel 38. Achieving the level of mitigation required to comply with the international obligations could therefore require a reduction in transmitted EIRP in areas close to the UK coast, improved transmitter filtering, the use of directional antennas or the use of some of the awarded spectrum as an effective guard-band to achieve a given level of transmit filter roll-off. Nevertheless, we consider that careful network design and the use of mitigation methods such as those indicated, should allow the implementation of a wide range of services across large parts of the UK. .

5.110 In summary we propose the following technical conditions will apply from the end of DSO to the licences awarded in frequencies occupied by channels 37, 38 and 39:

- Technical licence conditions which are the same as those proposed for other channels of the DDR cleared award, based on the 5 standard TLCs shown in Tables 5.1 to 5.5 above;

- A requirement to protect the use of channel 38 by international radio astronomy services to the levels given in ITU-R RA. 769-2. (This requirement may be removed in the event that obligations to protect international radio astronomy services are eased or lifted).

Protection of UK radio astronomy services

5.111 As described in section 4, we understand that the use of channel 38 by radio astronomy services in the UK will cease by the end of DSO. Until this use ceases, the two UK sites will need protection from interference caused by new licensees' transmissions. Table 5.9 below shows the separation distances that would be needed between the two UK radio astronomy sites and notional DVB and FDD/TDD base stations. As with the international sites discussed above, these separation distances provided are for information only and would not form part of the TLCs in licences, e.g. by specifying geographic exclusion zones. Once again we have given separation distances for single dish observation mode as this requires the most stringent protection levels. These distances reflect the fact that the UK Radio Astronomy Service agreed a 12 dB relaxation on the limits given in ITU-R RA.769-2, thus needing smaller separation distances between radio astronomy sites and transmitters from an interfering service.

Table 5.9: Separation distances between UK radio astronomy stations and DVB-T/DVB-H and FDD/TDD BS

	Separation distances for UK radio astronomy Single Dish Mode (km)	
Channel	**DVB-T/DVB-H**	**FDD/TDD base station[31]**
Co-channel (Ch 38)	500 (340)	630 (300)
Adjacent channel (Ch 37)	75 (20)	330 (100)
Adjacent channel (Ch 39)	250 (75)	380 (130)

NB: Separation distances shown in parentheses apply when 30 dB of mitigation is used.

5.112 As with the international protection requirements, these UK protection requirements are likely to preclude the use of channel 38 for any but low power transmissions over most of Great Britain. However even with mitigation, the deployment of FDD and TDD base stations in the adjacent channels 37 and 39 would be heavily constrained as well, and mitigation would be needed to enable a high proportion of the UK to be covered by broadcasting transmissions, particularly in channel 39. Accordingly it may only be commercially viable to roll out wider networks in these channels when the UK protection requirement ceases, which we assume to be by the end of DSO.

[31] The FDD/TDD channel bandwidth is assumed to be 5 MHz. The centre frequency is 611 MHz for a base station operating co-channel with the RAS, 603.5 MHz for channel 37 and 616.5 MHz for channel 39.

5.113 Until this time we propose to extend the licence condition requiring the protection of the international radio astronomy services to the levels given in ITU-R RA. 769-2 to the UK, but with the agreed 12 dB relaxation for UK sites.

Protection of PMSE services in channel 69

5.114 There are currently two main uses of channel 69 (854 MHz to 862 MHz):

- Shared and co-ordinated wireless microphones; and
- co-ordinated programme links.

5.115 As we set out in section 4, we envisage the continued use of channel 69 by PMSE for the foreseeable future. Accordingly we propose to apply standard TLCs across the DDR upper sub band. We believe the levels of protection afforded to radio microphone users should be satisfactory based on typical operating parameters of the most likely users of the digital dividend upper sub-band. However, we will consider further the implications of interference into programme link services which may be more susceptible than radio microphones to interference from some types of possible future digital dividend service. We will also consider interference implications of PMSE services into potential digital dividend services.

Transitional arrangements to protect Analogue TV

5.116 In the 2007 DDR Statement, we said that a new licensed use of channel 36 could start prior to DSO following the removal of the existing aeronautical radar in 2009. In indicating the early availability of channel 36 for transmissions before DSO in our December 2007 statement, we noted that this would be conditional on not materially degrading the reception of Five's analogue television service in this period. However, any such new service starting in channel 36 prior to DSO could potentially cause interference to reception of Five's analogue TV services that continue to use channels 35 and 37 before DSO.

5.117 We therefore undertook modelling of a notional mobile TV service in channel 36 to examine the extent of potential interference which could arise, and hence the level of protection that would need to be provided via licences using channel 36 before DSO. The modelling indicated that approximately 3% of Five's viewers in channels 35 and 37 in the relevant coverage area could potentially suffer from interference, ranging from almost imperceptible to a complete loss of picture. This analysis was based on the ability to sustain analogue reception within Five's served (core) coverage area.

5.118 Outside this served coverage area, analogue reception can still currently be achieved by using higher performance receiver systems. Five has stated that it derives significant revenue from viewers in these areas. These marginally-served areas will be more susceptible to adjacent channel interference, such as that which could arise from transmissions from channel 36 before DSO.

5.119 We consider that a similar protection clause in new licences should apply only to analogue reception in an existing broadcaster's served coverage area (above a wanted field strength of approximately 70 dBµV/m). We believe that it would be unduly onerous for new licensees to be required also to ensure protection of viewers in the marginally served areas. We believe that the time taken to roll out a national network following award of a licence in 2009, coupled with the regional phasing of DSO, will in practice mean that there would be only small numbers of affected analogue households in marginally served areas, and only a fraction of these would

be vulnerable to interference in the period between the start of any new transmissions from channel 36 and the end of DSO as it affects channels 35 and 37.

5.120 We believe that the protection clause approach proposed to protect PSB and commercial DTT services should also apply to the protection of Five's analogue TV services in its core coverage area in channels 35 and 37 in the period prior to DSO. The overall approach to this proposed clause was described in the context of DTT earlier in this section, with its implications discussed in Annex 6. We consider that this would be a suitable and efficient transitional protection mechanism for analogue services in channels 35 and 37 for the same reasons as apply to DTT protection.

Interference from existing DTT into new services

5.121 New services deployed in the DDR cleared spectrum channels which transmit in frequencies which are adjacent to existing DTT channels may expect to receive higher levels of interference from existing DTT transmitters than those which are not.

5.122 These higher levels of incoming interference from existing DTT services may then affect the levels of service that can be provided by networks using cleared spectrum frequencies, and/or on the cost of network deployment to achieve a given level of service (e.g. requiring higher-performing receiver filtering). These effects may change the value of this spectrum in comparison to spectrum further away in frequency from existing DTT transmissions, and hence is relevant to our approach to allocating the spectrum concerned.

5.123 We have therefore undertaken studies to investigate the levels of interference from DTT that might be experienced by the receivers of new transmissions in the cleared spectrum. Detailed discussion of the results of this work is given in Annex 8 and the various supporting study reports completed by our consultants.

5.124 Based on this work, we have concluded that channels that are adjacent to existing DTT are likely to suffer materially higher levels of incoming interference, but that nevertheless useful deployments of transmission networks can still be undertaken in these channels for the various services being considered. We therefore believe that it is preferable for the spectrum in the affected channels to be awarded via specific lot categories in the auction, rather than being retained or utilised as a guard-band. Accordingly we have adopted this approach in formulating our packaging proposals in section 7.

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

Compliance with SURs

5.125 In the 2007 SUR Statement, we stated our preference for using a modelling approach for compliance assessment with SUR type TLCs. We therefore intend to apply this approach to compliance assessment if TLCs in the licences for this award are expressed in terms of SURs. In May 2008, we published a supplementary SUR Statement setting out the licence verification approaches to be used under a range of interference scenarios. The modelling methodologies have been developed through consultation with stakeholders and through a series of stakeholder workshops.

5.126 Given the types of usage envisaged for the spectrum to be covered by the licences in this award, we propose to use the propagation models along with terrain and clutter databases listed below:

- Path loss for base station to mobile, base station to base station and mobile to base station interference scenarios: propagation model ITU-R P.1546-3.
- Path loss for mobile to mobile interference scenarios: propagation model ITU-R P.1411-4.
- Terrain database: Ordnance Survey "Panorama DTM" 50m resolution digital terrain map data.
- Clutter database: The 50m resolution clutter database produced by Infoterra.

5.127 The licences issued at the time of the award will contain the specific version of each propagation model and database to be used. If the propagation models and databases are then updated, the version stated in the licence will still be used for compliance purposes unless all relevant licensees (to be determined on a case by case basis) agree to a change to the latest version, subject to our approval. Further details pertaining to the general nature of the compliance process that is envisaged are given in the SUR statement published in December 2007.

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

Alternative form of technical licence condition

5.128 As mentioned earlier in this section, transmit masks represent an alternative form of TLC to SURs. Use of such an alternative form of TLC would not affect the other proposals in this section, including those relating to the management of interference with international neighbours, the management of interference between new services deployed in the DDR cleared spectrum using guard bands, and the management of interference between new and existing users using protection obligations. As explained earlier in this section, although both SUR and transmit mask TLC types are intended to control interference caused to neighbouring licensees, the two TLC approaches are different. This means that direct comparisons between alternative TLCs specified under the different approaches cannot be made. In particular the power flux density (PFD) limits specified in an SUR form of TLC will not be direct equivalents to the mask profile in a transmit mask form of TLC.

5.129 The standard TLCs that we propose in terms of SURs are specified in Annex 10 and summarised in Tables 5.1 to 5.5 in this section. While we are not proposing to offer transmit mask equivalents as TLCs in the award itself, they may represent useful guidance information for stakeholders. For this reason, the equivalent indicative limits for transmit mask type TLCs are given summarised below.

5.130 For DVB-T and MMS type licences, the out-of-band power profile would not exceed the non-critical (8 MHz channel) DVB-T mask as specified in the RRC-06 Final Acts.

5.131 For FDD uplink and downlink type licences, the maximum in-band transmitted power would not exceed 31 dBm/(5 MHz) TRP[32] and 61 dBm/(5 MHz) EIRP respectively while the maximum out-of-band emissions would be those in the appropriate ETSI standards (i.e. ETSI TS 125.101 and ETSI TS 125.104[33] respectively). This approach was used in the 2.6 GHz award. For TDD type licences, the maximum in-band

[32] TRP means the total radiated power. This is the integral of the power transmitted in different directions over the entire radiation sphere.
[33] For FDD DL type licences, the mask for a wide-area base station applies.

transmitted power would not exceed 31 dBm/(5 MHz) TRP and 61 dBm/(5 MHz) EIRP for uplink and downlink use respectively, while the maximum out-of-band emissions would be those in the appropriate ETSI standards (i.e. ETSI TS 125.102 and ETSI TS 125.105[34] for uplink and downlink use respectively).

5.132 In situations where standard TLCs do not apply, the equivalent TLCs in terms of transmit masks are given below:

- As discussed in Annex 7, a further restriction to standard TLCs is needed where a TDD licensee is a frequency neighbour of a FDD licensee or another TDD licensee to manage the risk of base station to base station interference. Accordingly, for transmit mask TLCs, the relevant transmitting base stations would be subject to an emission restriction of -45 dBm/MHz in the channel of the interfered party.

Question 16: Do you have any comments on the transmit masks set out in paras 5.130 to 5.132?

Conclusions

5.133 In this section, we have broadly assessed two alternative approaches to TLCs: SURs and transmit masks. Given the range of possible technologies and services for this award and the uncertainty in terms of expected interference levels, we believe that the SUR type of TLC is more suitable. This is because SURs set a direct limit on the level of interference that can be caused to neighbouring licensees regardless of the density of transmitter population deployed. This enables licensees to efficiently manage transmitter density and power in different locations to meet interference constraints. In addition, bidders in the auction will have greater assurance over the level of interference they can expect from their frequency neighbours, helping them to better identify the value of spectrum and hence assist in its efficient allocation in the auction. Furthermore, SURs protect against future potential changes in a neighbouring licensee's transmitter deployment density. This is particularly important in situations, like the DDR awards, of relative uncertainty over future possible changes to the use of the spectrum or network roll out timescales.

5.134 The following obligations would be inserted into all licences in the DDR cleared award (covering frequencies in channels 31-40 and 61-68):

- The need to respect international coordinated rights of transmission as specified in the GE-06 Plan, as it is amended from time to time. Proposed transmissions arising from new uses of the spectrum are likely to require re-coordination with neighbouring administrations if the field strength in the particular channel exceeds the agreed values at one or more geographic points defined in the extant version of the GE-06 Plan.

- A protection clause to protect defined DTT services planned to be transmitted after DSO from interference due to new transmissions in spectrum licensed in the DDR Cleared Award.

5.135 Licences offered for award will have TLCs for each of five separate generic types of transmission network, namely DVB-T, MMS, TDD and FDD mobile uplink and downlink. In most cases, the TLCs will be the same regardless of the specific frequency of the licence assigned to the licensee following the auction, whether in the

[34] For the downlink use of a TDD type licence, the mask for a wide-area base station applies.

middle of a block of similar TLCs, or at the edge of a block of similar TLCs (and therefore potentially neighbouring a licence with a different generic TLC type). We term such TLCs, "standard TLCs".

5.136 In addition, we have proposed a set of guard bands to manage interference between new services deployed in the DDR cleared spectrum and the interference between new and existing users. The proposed guard-bands are summarised in Table 5.10 below.

Table 5.10: Summary of the proposed guard bands in this award

Adjacencies	Guard-bands (MHz)
Like services	0[35]
New DVB-T – MMS	5
New DVB-T – FDD downlink	5
New DVB-T – FDD uplink	16
New DVB-T – TDD	16
MMS – FDD downlink	5
MMS – FDD uplink	19
MMS – TDD	19
FDD downlink – TDD	5
FDD downlink – FDD uplink	10
FDD uplink – TDD	5
Existing DTT – New DVB-T	0
Existing DTT – MMS	0
Existing DTT – FDD downlink	0
Existing DTT – FDD uplink	16
Existing DTT – TDD	16
RAS – All new licensees	0
PMSE – All new licensees	0

NB: A DTT protection clause will be specified for all the channels of the DDR Cleared award, and a RAS protection clause specified for channels 37, 38 and 39; PMSE services will be protected via standard TLCs

5.137 In addition to these proposed general provisions, additional requirements or obligations have been proposed to deal with specific circumstances:

- Because the UK does not already have international transmission rights in channel 36 under the GE-06 Plan, these will need to be established with the neighbouring administrations (where possible prior to the award) and reflected in channel 36 licences, alongside an extension of the protection clause to Five's analogue services in its core area in channels 35 and 37;

[35] However, a guard band of 5 MHz is specified between adjacent TDD operators.

- The licences for frequencies in channels 37, 38 and 39 will have an additional requirement to protect UK radio astronomy until the end of DSO in 2012 and to protect international radio astronomy on an ongoing basis;

- The licence for channel 38 will include a requirement to coordinate with licensees using channel 37 and channel 39 frequencies to mitigate the risk of interference into these channels. Bilateral agreements with neighbouring administrations to ensure protection of channel 38 in the UK from future incoming levels of interference will be necessary; and

- Where a TDD licensee is a frequency neighbour with another TDD licensee or another FDD licensee, a further restriction to standard TLCs is needed to manage the risk of base station to base station interference. Accordingly, for transmit mask TLCs, the relevant transmitting base stations would be subject to an emission restriction of -45 dBm/MHz in the channel of the interfered party.

5.138 New services in the cleared channels adjacent to existing DTT channels may experience higher levels of interference from the existing DTT transmissions than users of cleared channels further away from the existing DTT channels. These higher levels of interference may have an impact on the service provision and network deployment costs, and hence the value of the spectrum.

5.139 Alternative TLCs to SURs, in the form of transmit masks, have also been given for guidance purposes, although these are not proposed to be offered in the award. As well as expressing a preference for either of the two types of TLCs, stakeholders have the opportunity to provide their views on the parameters and the underlying assumptions used in the derivation of the TLCs set out in this section. They can also comment on the proposed propagation model and terrain/clutter databases to be used for compliance assessment of SUR licences.

5.140 We will publish a final set of proposed TLCs in a Statement taking account of stakeholder comments. However, licensees would then be allowed to change the TLCs in their licences, in the first instance, via negotiation with their neighbours where relevant and subject to variation by Ofcom. A more detailed description of the procedure to follow is given in the 2007 SUR Statement.

Section 6

Non-technical licence conditions

Introduction and summary

6.1 In this section we discuss non-technical usages rights that we propose to place in the licences that we will auction. In particular, we discuss our proposals on

- DTT multiplex issues – setting out certain ownership restrictions reflecting the regime applied by the Broadcasting Act 1996 and allowing us to facilitate interoperability between existing and any new multiplexes;
- Making the WTA licences tradable in secondary markets;
- Licence commencement and duration;
- The duration of the initial period, our limited rights for revoking the licence during this period and any additional powers we have following the initial period;
- Non-technical restrictions;
- Service obligations; and
- Provision of information to promote efficient use of spectrum.

6.2 Before moving on to the discussion on the non-technical proposals, we believe it is worth recapping on our December 2006 consultation proposals and the stakeholder responses. The December 2006 consultation document proposed a number of specific non-technical usage rights and obligations to be included in the Wireless Telegraphy Act licences to be awarded. These were:

- We proposed an indefinite licence duration, —with a initial term of approximately 18 years lasting until 2026 (subject to five years' notice of variation or revocation);
- We proposed that all licences would be tradable, with all legal forms of trading to be permitted;
- The licences would not restrict the technology or type of equipment to be used, or the service to be offered (other than the minimum technical restrictions necessary to control harmful interference); and
- We proposed that the licences should contain neither rollout obligations nor 'use it or lose it' conditions.

6.3 A small majority of responses favoured additional restrictions to ensure efficient spectrum use and promote diverse, non-discriminatory and inclusive use, particularly on a geographic basis to prevent an increase in the digital divide and for the services offered.

6.4 Most broadcasters thought that a minimum licence term of 12-18 years was needed, although other respondents felt that this was too long and that shorter terms were more appropriate to take account of new technologies and to maximise spectrum

efficiency. Broadcasters wanted licence terms aligned with those for the six existing DTT multiplexes.

6.5 Some community and consumer groups and individuals wanted provisions requiring demonstration of broader social value, to be transferred on any subsequent trade. Most respondents, particularly broadcasters and telecommunications operators, were keen that we formalise any arrangements to reduce interference risks.

6.6 We have taken the above responses into account when developing our proposals for this award.

DTT multiplex issues

6.7 The DDR consultation noted that the Communications Act gave us the power to operate a simpler and more flexible regime that would allow spectrum to be used to carry broadcast services such as those already available on the DTT platform.

6.8 Under this regime it is only necessary to hold a licence under the Wireless Telegraphy Act in order to operate a multiplex that may carry broadcast services. It is not therefore necessary also to hold a multiplex licence issued under the Broadcasting Act.

6.9 The DDR statement confirmed that we expected to use this new regime in relation to the digital dividend spectrum, removing the requirement for a person to hold a multiplex licence under the Broadcasting Act 1996. Content providers would however still need to hold the appropriate Broadcasting Act content licence.

6.10 The DDR statement also noted that we had considered whether it would be desirable to retain some limited elements of the Broadcasting Act regime, and that we would set out proposals in this consultation document regarding the inclusion of certain ownership restrictions to disqualify certain groups from operating a television or radio multiplex and to address interoperability between the existing DTT platform and any new television multiplexes using the cleared spectrum.

6.11 The proposals below apply equally to the geographic-interleaved and band-manager awards and the forthcoming consultation documents will set out the relevant proposals.

6.12 We have also considered whether there are other aspects of the obligations contained in Broadcasting Act multiplex licences that should be retained under the approach that we propose to adopt, of awarding licences under the Wireless Telegraphy Act only. In particular, Broadcasting Act licences typically contain conditions relating to competition.

6.13 However, we consider that the proper context in which to consider potential conditions relating to competition issues is in relation to a discussion of the effects of the award on competition more generally, and the potential effects on relevant markets. This is in section 9.

Ownership

6.14 We think that there are important reasons for considering whether to impose any restrictions on the identity of persons who may hold the WT Act licences that are the subject of this award for the purpose of operating a multiplex carrying broadcast services.

6.15 The fundamental point is that, whatever the technical and operational distinctions between existing DTT multiplexes (operated under both a Broadcasting Act licence and WT Act licence) and new DTT multiplexes (which may be operated under a WT Act licence only), the services that they provide may be indistinguishable in the eyes of viewers.

6.16 As noted above, content providers are required to hold the appropriate content licence issued under the Broadcasting Act. This requirement applies to content providers across all broadcasting platforms. At the platform level, however, Parliament has deliberately chosen to distinguish between the provision of those services via a multiplex —disqualifying certain categories of person from holding a Broadcasting Act multiplex licence—and via other networks (e.g. satellite and cable).

6.17 We consider that these rules were aimed primarily at minimising the potential for information or opinion to be distorted or manipulated. We also consider that, in relation to television multiplexes, these rules reflect viewers' familiarity with terrestrial television, and its importance as the mechanism for ensuring near-universal availability of public service content.

6.18 Categories of persons disqualified from holding broadcasting multiplex licences under the Broadcasting Act 1990[36] include the following:

- local authorities;
- political bodies;
- religious bodies;
- publicly-funded bodies;[37]
- bodies exerting undue influence;
- broadcasting bodies, specifically the BBC and S4C; and
- advertising agencies.

6.19 The Communications Act nonetheless obliges us to consider the ownership rules in relation to broadcast media at least every three years. It does so in the recognition that communications markets are developing rapidly and likely to continue to do so, which may in time mitigate the need for specific ownership restrictions and rules. Our first review in November 2006 concluded that there was no clear reason for such changes.[38]

6.20 We have borne these conclusions in mind in considering which, if any, ownership restrictions to apply to the use of the cleared spectrum to operate a DTT multiplex. At the same time, we have had regard to our duty to ensure our actions are targeted only at cases in which action is needed.

6.21 Where the cleared spectrum is used to operate a multiplex for carrying DTT services, we propose to:

[36] www.opsi.gov.uk/acts/acts1990/ukpga_19900042_en_1. Subsequently amended by the Broadcasting Act 1996, the Competition Act 1998 and the Enterprise Act 2002.
[37] Radio-service licences only.
[38] www.ofcom.org.uk/research/media_owners/rulesreview/rules.pdf.

- include ownership restrictions that replicate those in the Broadcasting Act relating to –
    - local authorities;
    - political bodies;
    - religious bodies; and
    - bodies exerting undue influence; but
- not to replicate the restrictions related to –
    - broadcasting bodies. This no longer appears appropriate given that BBC Free to View Ltd already holds a Broadcasting Act multiplex licence (for Multiplex B), and is directly under the control of the BBC;
    - advertising agencies. We do not believe it would be objectively justified to restrict persons in this class from holding a WT Act licence for this purpose as we do not see evidence that this would be likely to distort the market for advertising, and all content restrictions in relation to advertising will apply in any event via the regulation of content provision.

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

6.22 In proposing that we replicate the ownership restriction related to local authorities, we have been mindful of our position, set out in the DDR statement, that explicit support through direct funding for services that can provide broader social value is more transparent and can achieve a better outcome than reserving spectrum for those services. We therefore wanted to ensure that this ownership restriction would not work against any services (e.g. local television) that might require funding from such sources to be viable.

6.23 We believe that it is entirely feasible to separate funding of the acquisition of spectrum from the ownership of a DTT multiplex. The ownership restriction related to local authorities should not prevent potential funding from such bodies for those wishing to provide local television services provided the funding does not give rise to "*de facto*" control of a multiplex or "undue influence" adverse to the public interest.

- *De facto* control – this will arise if the funding arrangements put the provider of those funds in the same position as a controlling shareholder. This is more than mere influence, allowing the local authority to fulfil its wishes over and above other shareholders.
- Undue influence adverse to the public interest – there must be no influence exerted on the multiplex owner which may serve political or other ends. Limited financial assistance, in the form of a loan or grant, may be acceptable provided it does not result in the exertion of influence which is adverse to the public interest. Each grant or loan would need to be considered on a case by case basis.

6.24 We encourage bidders requiring direct funding to acquire this spectrum to think about how they can secure funds from a variety of sources (including but not limited to local authorities) and to ensure that they comply with all the rules relating to funding.

6.25 In considering how best to implement in Wireless Telegraphy Act licences the ownership restrictions which are equivalent to those currently included in Broadcasting Act multiplex licences, we will also need to consider whether any related conditions are required in order to enable us to monitor and audit compliance with the ownership restrictions imposed, for example, requiring the licensee to inform us of any change in ownership and to provide us with relevant information at our request regarding ownership, control and undue influence.

Interoperability

6.26 Viewers benefit from and greatly value being presented with a common service across all six existing DTT multiplexes. This outcome is achieved by the current framework under which the six multiplexes interoperate. This is necessary because the multiplexes are independent of each other, unlike vertically integrated platforms like satellite or cable, and so some cooperation between the multiplex owners is required to ensure that viewers on any particular multiplex are presented with a common set of services rather than the service offerings of that particular multiplex .

6.27 When the first DTT multiplex licences were awarded in 1998, the Independent Television Commission required compliance with its Technical Code and associated Community Digital Standards. These documents now exist as the Ofcom Television Technical Code[39] and Reference Parameters for Digital Terrestrial Transmissions in the United Kingdom,[40] which define the technical standards and operating parameters that the existing multiplex operators are required to adopt. The latter document details a subset of transmission standards agreed within the European Telecommunications Standards Institute (ETSI) to which operators should adhere:

- frequency parameters – what kinds of signal are used to carry a multiplex (e.g. DVB-T, 64QAM);
- encoding standards – how the programmes carried in the multiplex are put into a form suitable for broadcasting (e.g. MPEG-2, MPEG-4);
- service information – the data stream normally invisible to viewers that is essential for receivers to operate. Some parts of the stream are used to populate the Freeview electronic programme guide (EPG), allowing viewers to obtain up-to-date information on all DTT services regardless of what they are watching;
- Application Programme Interface – the software that displays graphics and enables interactive services to function (e.g. MHEG-5); and
- access services (e.g. subtitling).

6.28 At the same time, there is focused voluntary cooperation on the part of the multiplex operators in addition to compliance with the two documents mentioned above. This takes place through the Digital Television Group (DTG),[41] which publishes, maintains

[39] See http://www.ofcom.org.uk/tv/ifi/tech/codes_guidance/tv_tech_platform_code.pdf
[40] See http://www.ofcom.org.uk/tv/ifi/tech/codes_guidance/dttt_uk2.pdf
[41] DTG is the industry association for digital television in the UK. It is independent and platform neutral. It was formed in the mid-1990s to facilitate the introduction of DTT in the UK and has a wide

and promotes adherence to the D-Book, setting out the detailed technical standards for DTT in the UK, and runs the sector's test and conformance centre. The operators also pay for and maintain equipment such as the Central Service Information Collator, which combines information on programmes on all the multiplexes to produce the service information broadcast on each.

6.29 Against this backdrop, and given the possibility that cleared spectrum will be used to deliver new DTT services, we have considered the issue of interoperability with the existing multiplexes and the extent to which regulatory intervention may be needed to secure this. We have identified three options:

- **Do nothing**. Under this option, interoperability would only arise through the voluntary agreement of existing and new multiplex operators. It could be achieved by new operators adopting the same technical standards and operating parameters as existing operators and existing operators adapting their systems as necessary to accommodate new operators. Given that under this option interoperability will only arise if the new and existing multiplex operators can reach agreement, there is some risk that it will not be secured in the future. Our initial view is given that in the past consumers and citizens have benefited from the existence of interoperability arrangements it is likely to be unattractive to take this risk. It has therefore identified two further more proactive options.

- **Facilitate**. Under this option, we would require existing multiplex operators to interoperate with new operators at the request of the latter. We would propose to vary existing operators' Broadcasting Act licences if necessary to achieve this. If new operators wished to take advantage of this opportunity, they would need to operate within the same technical code and operating parameters as existing operators. They would not therefore be free to adopt some aspects of the technical code and operating parameters while rejecting others. (However, the technical code and operating parameters themselves include a number of choices open to multiplex operators.) This option preserves some flexibility for the new operators since it is not overly prescriptive about whether and when interoperability is achieved but it would set out a clear expectation that it will occur subject to the choice of new operators. It also would enable us to intervene if circumstances frustrate such agreements being reached. It does not, however, guarantee viewers the benefits of interoperability across all multiplexes and nor that this will happen at the earliest possible time. We stress that we would expect new operators gaining interoperability in this way to play a full role in the maintenance and promotion of the DTT platform rather than adopt a pick-and-mix approach to its individual components;

- **Mandate**. Under this option, we would require existing and new operators to interoperate in full as specified by Ofcom both in terms technical standards and the time at which it should be achieved. Again, new operators would need to adopt the same technical standards and operating parameters as existing operators, while we would vary existing operators' Broadcasting Act licences as necessary. This would guarantee viewers the benefits of interoperability across all multiplexes but at the expense of automatically precluding alternative market offerings that could deliver different, possibly greater benefits. As yet we are not aware of a compelling reason to intervene to this extent.

---

membership including Ofcom, multiplex operators, broadcasters, consumer bodies and equipment vendors.

6.30 On balance, our initial view is that interoperability is likely in the future to bring benefits to consumers and citizens as it has in the past. Therefore, if the spectrum is to be used for new multiplexes we consider it appropriate to take some steps to encourage the emergence of interoperability so that those benefits are realised in relation to such new multiplexes. However, our preference is for the industry to secure this itself within a framework set by Ofcom rather than for Ofcom to mandate interoperability. Accordingly, we propose to facilitate interoperability between existing and new multiplex operators at the request of the latter.

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

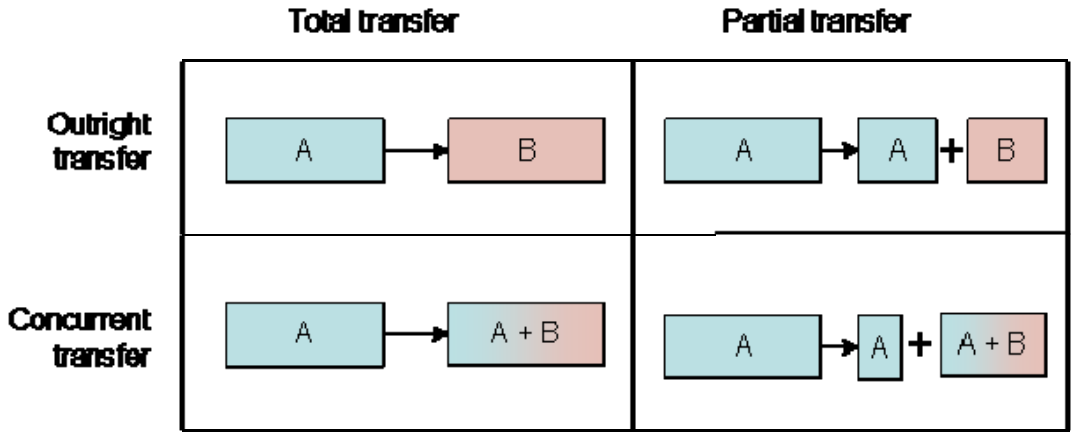
Spectrum trading

6.31 We began the implementation of spectrum trading for selected licence classes in 2004, through the Wireless Telegraphy (Spectrum Trading) Regulations 2004 . The changes, described in the Spectrum Trading Statement, published in August 2004, introduced the possibility for licensees in specific classes to carry out:

- outright total transfers, i.e. transfers of all of the rights and obligations arising under a licence to a third party;
- concurrent total transfers, i.e. transfers of all of the rights and obligations arising under a licence to a third party which result in a concurrent holding of those rights and obligations by the transferor and the transferee(s);
- outright partial transfers, i.e. outright transfers of some of the rights and obligations arising under a licence to a third party; and
- concurrent partial transfers, i.e. transfers of some of the rights and obligations arising under a licence to a third party which results in a concurrent holding of those partial rights and obligations by the transferor and the transferee(s).

6.32 Figure 6.1 illustrates these four generic types of transfer.

Figure 6.1 Illustration of some possible types of transfer



6.33 In the case of the licences for the cleared spectrum, we propose to amend the Wireless Telegraphy (Spectrum Trading) Regulations to allow all of the above types of transfer to occur for the licences awarded.

6.34 It should be noted that trading is not currently possible in Jersey (because Section 30 of the Wireless Telegraphy Act does not extend there) or Guernsey (because, while Section 30 of the Wireless Telegraphy Act does extend there, the Wireless Telegraphy (Spectrum Trading) Regulations 2004 do not). We are talking to the authorities in both islands about their expressed interest in introducing trading, at least for licences for the spectrum subject to this award. Section 7 considers the award of this spectrum in the Crown Dependencies.

Licence commencement and duration

6.35 It was proposed in the Spectrum Framework Review: Implementation Plan that new licences to be awarded by auction should generally have an indefinite term with a initial term. During the initial period the grounds for revocation would not include a general right to revoke for spectrum management reasons. After the end of the initial term, the grounds for revocation would include such a right, subject to a minimum notice period of five years. We also proposed that notice of revocation for spectrum management reasons could be given so that the licence ended the day after the expiry of the initial term.

6.36 The aim of these proposals was to provide licensees with a initial term during which they would have high security of tenure, and grounds for revocation would be limited to a narrowly defined set of conditions. The period of the initial term should be linked to a reasonable view of the period required efficiently to earn an appropriate return on the investment anticipated for efficient use(s) of the spectrum, and take into account any other factors that are relevant. The aim of proposing an indefinite duration was to give the licensee the opportunity to continue operating its business beyond the initial term. However, during this period we would be able to recover the spectrum by serving a notice of revocation in a similar manner to many other spectrum licences, if this step was justified on spectrum management grounds. In addition we would reserve the right to charge AIP in this period to incentive efficient use of the spectrum.

6.37 We consider that there are a number of reasons why licences with an indefinite term are likely to promote optimal use of the radio spectrum and other relevant objectives, including the promotion of competition.

6.38 In particular, the award of licences with an indefinite duration reduces the need for regulatory intervention to reassign spectrum at the end of the licence term. One disadvantage of fixed term licences is that at the end of the licence term the licence expires and so the rights to use it must be returned to the regulator, unless any other action has been taken. This may result in a period during which the spectrum remains unused as the regulator must go through a process to reassign those rights. Furthermore, incentives to invest closer to the end of a licence term are significantly reduced given that communications networks generally require continual investment. This lack of investment could result in detriment to consumers and citizens. The alternative of licences with an indefinite duration removes the requirement for return to the regulator, removes the risk of discouraging investment and creates additional opportunities for the market to secure the efficient use of the spectrum, particularly in the presence of spectrum trading.

6.39 We consider that, as a matter of principle, it is preferable to look to market mechanisms to promote the efficient use of resources rather than regulatory intervention, unless the case for such intervention is clear. To date we have not identified a general need for us to recover spectrum at the end of the initial term in relation to any of our spectrum awards.

6.40 We consider that there are likely to be a number of other advantages to adopting the general approach proposed above. In particular, reassignment by the regulator typically takes significant time and resource. The spectrum may also lie idle for a period as the regulator prepares for reassignment. While it may be possible to reduce this problem through the use of overlay auctions, the approach of an indefinite term together with spectrum trading seem likely to offer a simpler and less costly way of ensuring the spectrum is used efficiently.

6.41 We therefore favour offering licences with an indefinite duration for the cleared spectrum. The retention of powers to revoke on spectrum management grounds provides a mechanism allowing regulatory intervention if this is justified in particular cases

6.42 The inclusion of an initial term in the licence is desirable in order to give sufficient certainty to investors to incur the necessary costs to put the spectrum into use. Without a initial term there is a risk that this may not occur and so the spectrum would not be used efficiently.

6.43 Consistent with the above general policy framework, we propose to take the following approach in respect of duration for licences issued for spectrum subject to this award:

- the licences to have an indefinite duration;
- the licences to have a initial term of a specified duration, as discussed below;
- we will be able to revoke the licences before the expiry of the initial term on the limited grounds set out below; and
- we will be able to revoke the licences from any point after the expiry of the initial term on the grounds set out below, but also for spectrum management reasons subject to us giving five years notice; it will be possible for us to give notice of revocation during the initial term, for revocation to take effect after expiry of the initial term.

Rights to revoke licences during the initial term

6.44 The initial term is designed to provide licensees with a high security of tenure for investment planning purposes. During that period, we will not be able to revoke licences for spectrum management reasons and will only be able to do so in the particular circumstances described below.

6.45 During this initial term the licence may only be revoked for the following reasons:

- with the consent of the licensee;
- for non-payment or late payment of the relevant licence fee;
- if there has been a breach of any of the terms of the licence;
- if the licensee has not complied with any requirement of any relevant trading regulations;
- if the licensee has not complied with the auction regulations under which the licence was awarded, including any financial provisions including guarantees;

- we may at any time, by notice in writing, revoke or vary licence terms if it appears to us to be requisite or necessary or expedient to do so in the interests of national security, or for the purposes of complying with a Community obligation of the UK or with any international agreement or arrangements to which the UK is party; and

- if it appears requisite or necessary or expedient to do so for the purpose of complying with a Direction by the Secretary of State under Section 5 or Section 156 of the Communications Act 2003.

Additional powers after the initial term

6.46 When the initial term has expired, the licence will remain in force and continue to be held by the licensee. Two additional conditions would then also apply:

- one relating to additional licence fees that we expect to be payable after the end of the initial term; and

- one providing an additional power to allow us to revoke or vary the licence on spectrum management grounds.

6.47 We consider these in turn below, addressing first the position in relation to fees after the initial term, and then the power to revoke on spectrum management grounds.

6.48 Our expectation is that, after the end of the initial term, licensees who wish to hold the licences issued under this award will need to pay additional licence fees. The level of these fees will depend on our general approach to fees for the use of spectrum at the time, and how that general approach relates to these licences and to our statutory duties at the time. The level of the fees cannot therefore be determined now. However, our expectation is that it will be appropriate to set fees based on Administered Incentive Pricing (AIP). The reasons for this are explained in more detail below. We also expect fees, as a minimum, to be sufficient to make an appropriate contribution to the costs of regulation.

6.49 AIP presently plays an important role in incentivising the efficient use of spectrum, and is widely applied to licences to use spectrum. Indeed, we have recently stated our intention to extend AIP to certain types of spectrum use that do not presently face AIP (such as terrestrial broadcasting and certain aeronautical and maritime uses). We have also stated that, in general, we expect to continue to apply AIP to licences after they have been made tradable, and that AIP may also be applied to licences that have been auctioned by us, after the end of the initial term. This is because the application of AIP is likely to promote efficient use of the spectrum, by sending very clear and tangible signals to users about the opportunity costs of using spectrum.

6.50 In relation to the licences that are the subject of this award, our view is that the application of AIP after the end of the initial term is likely to help secure the efficient use of the spectrum in the long term. This is because the application of AIP should be a complement to other policies designed to secure efficient use of the spectrum, notably the policies of awarding the spectrum by auction, and of making the spectrum licences tradable and liberalised. We consider that the advantages of applying AIP after the initial term are likely to outweigh any disadvantages, provided AIP is set at a level that is unlikely to deter efficient use.

6.51 We have taken account of the importance of the spectrum that is the subject of this award in considering this matter, and its usefulness for a wide range of applications.

It is important to note that we would expect to give prior notice of our specific proposals to charge fees, and to consult as appropriate, before fees are introduced.

6.52 We also consider that it is appropriate for us to have wider powers to revoke or vary the licences that are the subject of this award after the end of the initial term. This reflects the greater uncertainty that will exist in the more distant future about the conditions that will make for optimum use of spectrum. We consider that market mechanisms should promote efficient use of spectrum, and be much more successful in this respect than widespread reliance on regulatory controls. The tradability and liberalisation of spectrum are key elements of a market-based approach. However, there may be circumstances in which additional intervention is justified in the public interest (for example, to overcome a specific market failure such as problems of co-ordination caused by high transaction costs).

6.53 We consider that it is in the public interest for us to have a greater power to take regulatory action, if justified, in relation to the use of the spectrum in the long term. This can be achieved by having an additional power to revoke or vary the licence on spectrum management grounds after the end of the initial term.

Duration of the initial term

6.54 As mentioned above, the initial term should be linked to a reasonable view of the period required to efficiently earn an appropriate return on the investment anticipated for efficient use(s) of the spectrum. We have considered the relevant period that might provide a reasonable chance for the businesses that might be most likely to operate in the bands to make an appropriate return on efficient investment without unnecessary regulatory risk.

6.55 Analysis already undertaken in connection with previous awards and our December 2007 Statement suggests that the minimum operational term of a licence supporting substantial new investment in a network would need to be in the region of 15 years. This approach was used in our 10-40GHz and L Band Awards. This is also in the middle of the range suggested by broadcasters in response to our December 2006 Consultation. Without a degree of certainty that they will be able to offer services for at least this sort of period of time, licensees are unlikely to be willing to make the investments necessary to efficiently exploit this spectrum.

6.56 At the same time use of the cleared digital dividend spectrum will not be possible on a UK-wide basis until 2012, with for example use in London not being possible before then. If licensees are to have a reasonable prospect of earning a commercial return on their investments they will therefore need a reasonable degree of certainty that they will be able to continue offering service through to around 2027.

6.57 We also consider that there are a number of factors which are relevant to determining the initial term. The first of which is three of the current DTT multiplex licences, if renewed, will reach the end of their renewed term in 2026 (12 years from 2014). We think there is merit in synchronising the end of the initial term for the new licences to be awarded for the digital dividend spectrum with the end of the renewed term for these existing DTT multiplexes which could enable a comprehensive assessment of the efficient use of the UHF spectrum at that time.

6.58 The majority of respondents to the December 2006 DDR consultation agreed with our proposal on linking the initial term with the expiry date of the three existing multiplexes.

6.59 We therefore propose that the initial term for the new licences to be awarded for the digital dividend spectrum should end in 2026.

6.60 We propose that the rights to the spectrum cleared as a consequence of DSO should begin with effect from completion of DSO in each region. We have no reason to suppose that DSO will be delayed. However if a delay does occur this will lead to a corresponding delay in the date from which the new rights to use of this spectrum can take effect.

Non-technical restrictions on use

6.61 In the light of our intention that the cleared spectrum be available on a service- and technology-neutral basis, we do not propose to impose any non-technical restrictions on the use to which the spectrum could be put in the licences (such as specifying the service that could be offered, the technology that could be deployed or the equipment that could be used).

Service obligations

6.62 Section 9 discusses the appropriateness of 'use it or lose it' conditions and roll out obligations. For reasons explained there we do not propose to impose either of those obligations in this award. This is consistent with our general policy statements[42] which explain that such conditions are unlikely to be justified as a means to promote optimal use of the spectrum. These statements explain that optimal spectrum use would instead be better achieved through other market-based mechanisms such as a competitive award process, spectrum trading, liberalisation and spectrum pricing.

Provision of information to facilitate optimal spectrum use.

6.63 In line with our duty to manage the spectrum efficiently, we propose to include a standard condition in the licences for the DDR cleared spectrum 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 this spectrum to identify areas where they may provide additional services by trading with licensees in that band.

6.64 We consider that this approach is objectively justified to fulfil our statutory duties and objectives, transparent, proportionate and does not discriminate between licensees. The justification for this licence condition is also discussed in section 9.

6.65 We are currently investigating the type and scope of information that it would be useful to provide for this purpose. Therefore, we are particularly interested in the views of stakeholders on what information they think would help to facilitate efficient use of spectrum and secondary trading, and on the impact of the disclosure of this information might have on licence holders. In this respect there are a number of relevant considerations to bear in mind:

- The extent to which information provided might fall under the scope of the Environmental Information Regulations;

[42] http://www.ofcom.org.uk/consult/condocs/sfrip/sfip/sfr-plan.pdf

- The ways in which spectrum usage and spectrum assignments can be compared, in order to identify unused spectrum in a meaningful way to external stakeholders (particularly in comparing cleared and interleaved spectrum usage);

- The wide variety of potential uses of the spectrum concerned, each of which might require different types of transmission network and use different business models to define affected customer bases (e.g. free-to-view broadcast transmissions versus subscriber-based business models);

- The restrictions that might need to be placed on published information to preserve as far as possible appropriate commercial confidentiality and satisfactorily address security concerns;

- The balance which needs to be struck between information which is specific to the digital dividend spectrum and (potentially more limited) information that is comparable across a wider range of bands; and

- The benefits of providing users with as much useful information as possible versus the costs and risks of users providing data, and our aggregating and presenting data in particular formats (e.g. to enable ready geographic comparison of usage and allocation data in particular frequencies).

6.66 In relation to the latter two considerations, we are currently examining the issue of spectrum information provision more widely and plan to publish consultation proposals later this year. However, we will be able to take account of responses to this consultation in developing our more general proposals.

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

Conclusions

6.67 The main specific non-technical conditions that we are currently minded to include in the WTA licences to be issued for as a result of the DDR cleared spectrum award are:

- licence term – indefinite, with a initial term lasting to 2026 during which we will have limited rights of revocation;

- provisions for us to revoke licence on spectrum management grounds on any date after expiry of the initial term, subject to 5 years' notice and to apply AIP after expiry of the initial term if appropriate;

- tradability – the licences to be tradable; all legal forms of trading to be permitted;

- a standard licence condition requiring licensees to provide us on request general information regarding their equipment and use of frequencies, or roll out of their network;

- non-technical restrictions on use – the licences to not restrict the service to be offered or the technology or type of equipment to be used (other than the minimum technical restrictions necessary to control harmful interference); and

- the licences will not contain roll-out obligations or ‘use-it-or-lose-it’ conditions

Section 7

Spectrum packaging

Introduction

7.1 In this section we describe a number of key choices which must be made in determining the packages of rights and obligations we will make available via wireless telegraphy licences to be awarded in the DDR cleared award. We identify, in each case, our preferred choice, and set out the implications for the packages that we propose to make available.

7.2 These choices are defined by the specific features and characteristics of the spectrum included in the DDR cleared award.

7.3 On the one hand, the packages of spectrum made available via licences should, as far as possible, reflect the potential demand for the spectrum concerned. We described our latest understanding of the nature of this demand in section 4

7.4 On the other hand, the packages must also reflect the specific constraints that apply to the spectrum available for award. These reflect a combination of international constraints and some UK-specific constraints which arise due to the use of adjacent frequencies after DSO, as described in section 4. We set out, in section 5, how we propose to reflect these constraints within technical licence conditions, to ensure the cleared-award licensees do not transmit harmful interference to their geographic and frequency neighbours.

7.5 Finally, the packages must reflect the other specific rights and obligations that will be included in the licenses that will be awarded by auction and which will therefore define the specific lots that we will make available in the auction. The key non-technical conditions that we propose to include in the licences for the DDR cleared award were set out in section 6.

7.6 However, after taking into account the licence conditions set out in sections 5 and 6, a number of key choices remain in determining the packages to be included in the DDR cleared award. These are evaluated in this section, with the conclusions then reflected in the auction design options set out in section 8. These key choices are:

- The frequency sizes of lots
- The frequency specificity of lots
- The packaging rules imposed for efficiency purposes in the award
- The geographic scope of lots.

7.7 We discuss our proposals in relation to each of these in this section, before drawing together the conclusions for cleared award packaging. However we first briefly summarise the work on these areas to date, to provide context for the choices examined in the rest of this section.

Work to date

7.8 In our December 2006 consultation we explained that the key extant international constraints of relevance were set out in the GE-06 Plan. We have set out the current international position in this area in sections 4 and 5. Because this Plan defines constraints in terms of existing 8 MHz broadcasting channels, we proposed that cleared-spectrum packages consist of one or more of these channels. Because there was no significant expression of demand for packages that combined cleared and interleaved spectrum at the time, the packaging of cleared spectrum was considered separately.

7.9 The DDR consultation in December 2006 discussed the respective merits of defining a series of individual 8 MHz lots, versus a smaller number of larger lots (in frequency terms). We suggested that a small number of large lots entailed a high risk of inefficient spectrum allocation, given the range of competing uses for the spectrum, many of which require less spectrum, and the risks attached to relying solely on an emerging secondary market to resolve reallocation issues. On the other hand, a large number of small lots would increase the risks of interference, by multiplying the number of potential boundaries between licensees, and would require a more complex auction. At the time, it was not clear that users would require lots as small as 8 MHz, so that such additional risks and complexity might not be need to be incurred to achieve efficient spectrum allocation.

7.10 The consultation also explored the issue of the geographic coverage of licences in the DDR cleared award. A general stakeholder preference for UK-wide licences, and the potential technical problems presented by licences with a smaller coverage, were both noted. In addition, while there might be demand for spectrum suitable for regional broadcasting, the emerging secondary market would potentially operate more effectively at disaggregating and customising UK-wide spectrum awards than enabling the aggregation of UK-wide licences from regional elements. We therefore expressed a preference for UK-wide licences in the DDR cleared award.

7.11 The responses to the consultation, a summary of which we published in May 2007, highlighted the uncertainties that existed in a number of areas, including the future pace and shape of European harmonisation, which made it difficult for stakeholders to provide specific and detailed responses on packaging and lot sizing issues.

7.12 In general, the benefits of greater flexibility offered by a larger number of smaller lots were noted, as well as the improved ability of such options to address competition concerns. However, the views of different stakeholders inevitably reflected their own spectrum requirements – PSBs favouring larger lots (to avoid any aggregation issues associated with acquiring sufficient spectrum for a DTT multiplex) and mobile television and telecommunications sectors preferring smaller lots. The suitability of a single 8 MHz channel for mobile television use was highlighted by respondents, for example.

7.13 In respect of geographic scope, the Advisory Council for Northern Ireland (ACNI) suggested that demand and spectrum considerations might justify a specific approach for Northern Ireland. Consumer bodies and community groups noted that UK-wide licences were inappropriate for more local media.

7.14 Taking these responses into consideration, our December 2007 policy statement confirmed that we would develop packages that allowed the widest possible range of users to compete at auction, to allow the market maximum opportunity to determine the best allocation of cleared spectrum. We identified the interleaved spectrum as a

source of packages suitable for sub-UK DTT and we confirmed our preference for UK-wide licences for the DDR cleared award, but noted that we were discussing our DDR proposals with the Irish authorities.

Frequency size of lots

7.15 In order that an efficient award of spectrum is made, it is important to ensure the lot sizes chosen for award represent as far as possible those minimum contiguous frequencies which potential bidders are likely to require.

7.16 As explained above, large lots entail a high risk of inefficient spectrum allocation, given that some uses for the spectrum require less spectrum, but a larger number of smaller lots will increase the risks of interference, by multiplying the number of potential boundaries between licensees, and would require a more complex auction. An appropriate balance therefore needs to be struck.

7.17 We propose that a sensible balance is to employ lot sizes that reflect current understanding of the minimum contiguous frequency required for those services where there is reasonable evidence of demand for the spectrum. Such lots can then be aggregated together if required for the deployment of services with wider bandwidth requirements.

7.18 In the DDR cleared award, potential providers of the different services we are considering have different preferences in this respect:

- DVB-T type technology currently operates in 8 MHz channels, and on an existing 8 MHz rasterised band plan.

- MMS type technology can utilise a number of bandwidths. For example the DVB-H standard allows a range of channel sizes, including 6, 7 and 8 MHz as standard while MediaFLO can operate with 5, 6, 7 and 8[43] MHz channels. With this choice we propose that 8 MHz is adopted for MMS, on the basis that this can if required be aligned more efficiently with the existing DTT channel raster (on which, for example, channel 36 will become available next year), while also maximising the data-rate of the potential services.

- TDD and FDD variants of two way communications technologies that are currently specified in Europe are likely to operate on a basis of 5 MHz channels or multiples thereof. Current technology uses a 5 MHz channelisation. Although WiMAX and LTE technologies are specified to have flexible channel bandwidths from 1.25 to 20 MHz, the standards for LTE in UHF Bands IV and V in Europe are not currently proposed to be established until after the planned timing of the DDR cleared award. On the basis that demand is for provision of wide-band services, we propose that 5 MHz is considered as a base channel size for TDD and FDD two way communication services.

7.19 In considering these channel size options in relation to auction design, there will always be a tension between being able to cater for known and developed technologies, and being flexible enough to cater for future and less certain possibilities. For example, the greater bandwidth flexibility offered by LTE technology has stimulated a debate within CEPT over the exact basis of flexible non-mandatory guidance on channelisation for the 790-862 MHz sub-band (channels 61-69), with the alternatives of 8 MHz and 5 MHz channels both being suggested.

[43] As reflected by 2008 stakeholder research – see section 4 for more details

7.20 Rather than favour either an 8 or 5 MHz lot size and hence potentially favour one service or another in terms of auction design, we propose to adopt both 8 and 5 MHz channel sizes for specified TLC types. This has two principal advantages. Firstly it maps the channel sizes awarded efficiently to the more likely services which we believe could be deployed in the cleared spectrum. This will minimise the chance that bidders need to buy more spectrum than they require to provide the services they wish to deploy. Secondly this arrangement ensures better spectrum efficiency, through being able to pack the differing services for which there is currently expected to be demand more closely into the cleared spectrum. In this way we would be able to meet our duties in respect of optimal use of the spectrum whilst at the same time accommodate the current and expected demand for the spectrum in a way which seeks to maximise the total value to society generated by it.

7.21 In summary, we believe that it is most practicable to package the lots suitable for DVB-T and MMS in individual 8 MHz blocks. This block size is appropriate for DTT and is preferred by MMS operators. Aggregation of these minimum block sizes – secured via package bids in a combinatorial auction, and/or secondary trading after the auction - can then be used to provide wider band services, for example multi-frequency DVB-T multiplexes, using a series of channels.

7.22 For both TDD and FDD variants of technical licence conditions suitable for two-way mobile communications services we consider that block sizes of 5 MHz should be offered in the auction. This again represents the minimum likely block size that any mobile communications service would employ in UHF bands IV and V, and represents a feasible base block size from which larger contiguous blocks can be aggregated if required, for example to provide WiMAX or UMTS or LTE services. Because the prospects of industry standardisation of future technologies around larger minimum block sizes (e.g. 8 MHz versus 5 or 10 MHz for LTE) are very uncertain and unlikely to be confirmed before the DDR cleared award is due to take place in 2009, we do not propose to offer licences with FDD or TDD TLCs with larger block sizes, although will finalise decisions on this issue in the light of consultation responses and wider industry developments before the award.

7.23 Finally, we propose to make lots of these sizes available for award across the cleared spectrum. This is because it is not possible to assess in advance whether demand for one type of application or technology will predominate in the auction in any sub-band, even though there are likely to be preferences by individual bidders for particular sub-bands.

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

Frequency specificity of lots

General considerations

7.24 Where spectrum use is harmonised within a particular band (by the market and/or as a result of regulatory intervention), there may be little difference in the value of obtaining rights to transmit at one frequency or an adjacent frequency within the same band. Transmit and receive equipment can typically be designed and deployed to operate at the different frequencies concerned, particularly where there is a lead time between acquiring spectrum and bringing equipment into operation. In these cases bidders in a spectrum award can be relatively indifferent as to exactly which frequencies they obtain.

7.25 Under such circumstances there are auction design reasons for defining lots which are "generic" as to the frequency concerned – that is, where the lots do not specify the exact frequency that will be awarded in advance. This helps to achieve the most flexible and efficient accommodation of demand to available spectrum capacity, in line with our statutory duties.

7.26 The most obvious auction design reason is that the auction is simpler for bidders – who only need to bid and express preference for an absolute number of lots, and not exactly where in the spectrum they need them. Combinatorial bidding may still be appropriate, where some bidders require a minimum amount of contiguous or non-contiguous, or paired or unpaired, spectrum with associated specific technical conditions. However, even in such cases the number of lot categories will be limited and bidders may typically only need lots in one or two of these technical categories.

7.27 A further benefit of having frequency-generic lots is that such an approach can also facilitate efficient spectrum allocation outcomes, arising as a result of auctions and/or secondary trading.

- First, a more flexible auction is facilitated so that a greater variety of bidder requirements can be simultaneously accommodated. The risks of bidders being left stranded, or lots being left unsold, are lower than with frequency-specific lots.

- Second, even where the auction itself does not realise a fully efficient allocation (for example due to incomplete market information), secondary trading in more homogenous licences is facilitated.

7.28 Auction rules can be designed automatically to assign guard bands between frequency-generic licences with different technical conditions, allowing the market the maximum opportunity to signal the most valuable distribution of spectrum between these different licence types. Where it is efficient for licences of the same type to be clustered in frequency terms, this can be encouraged to emerge as an outcome of the bidding process.

7.29 The proposed format of the 2.6 GHz auction illustrates the application of auction rules to frequency-generic lots in this way. This format allows the minimum number of guard bands required between FDD and TDD uses of the spectrum, and different TDD users, to be located at frequencies which are determined by the relative aggregate demands for the different types of frequency-generic lots concerned. In this way, the frequency locations of the guard bands do not need to be pre-set in advance of the market revealing the relative demands concerned in the auction.

7.30 Having a number of frequency-generic lots of the same type in an auction also explicitly helps to address the threshold risks to which smaller bidders might otherwise be exposed. Such bidders (which might collectively have the highest-value demand for the spectrum) could otherwise be squeezed out by package bids from larger bidders. Such risks can be exacerbated by strategic bidding behaviour.

7.31 By reducing the number of categories of lots, the likelihood of multiple bidders for a given category of lot increases, and with it the opportunities for value information to be revealed to bidders during a multi-round open auction are maximised. In turn this reduces the risks of unsold lots and insufficient price revelation. And if a multi-round auction is then followed by one or more sealed bid stages, where specific packages can be valued in secret by individual bidders, the existence of generic lots in the primary stage makes it very difficult for bidders to infer final outcomes, and hence to

make decisions (such as to withdraw from the process) based on expectations of other individual bidders' behaviour.

7.32 Despite these significant advantages, the practical constraints associated with cleared spectrum are likely to limit the extent to which completely frequency-generic lots will be efficient across this particular band. Fundamentally, where frequency significantly affects the value of an individual lot (regardless of the particular auction outcome), definitions of lots which ignore such value differences are likely to be inefficient: the different lots are no longer close substitutes for each other at any stage of the auction.

7.33 There are serious efficiency consequences for auction design when significant value differences are not reflected in lot categorisation:

- Auction bidders will be faced with significant exposure risks – that they win lots at the wrong frequencies, or lots which are not contiguous, or are located adjacent to licences for different types of use. To deal with these risks, bids are likely to be shaded down and not to reveal value truthfully, leading to inefficient allocation outcomes;

- Aggregation risks are likely to remain, even if bidders shade bids down to try and manage them, so that for example bidders can have insufficient eligibility from one stage in an auction to bid for exactly the frequency-based packages of lots they require in a subsequent sealed-bid stage;

- Different bidders and types of bidder would be differently affected by making lots frequency-generic, with those requiring larger amounts of contiguous spectrum in particular parts of the band effectively at a disadvantage in the auction to those with more flexible requirements (who would need to shade their bids by less). Accordingly, failure to reflect value differences adequately could reduce the competitiveness of the auction.

7.34 Accordingly, the decision on how many auction lots to make frequency-specific is a critical auction design judgment, which requires a careful balance of the advantages and disadvantages of frequency-generic lots in the specific circumstances of the auction format selected, for the specific spectrum being awarded. We therefore examine this question in the context of packaging decisions which reflect differences in lot values in this section, but then return to this decision in section 8 in assessing the feasibility of different auction designs to allocate the resulting spectrum packages efficiently.

Award-specific considerations

7.35 There are three broad options for the frequency-specificity of lots:

- making them all frequency-specific;

- making them all frequency-generic; or

- a hybrid approach where some lots are frequency-specific and others are frequency-generic.

7.36 The choice between these options will depend on the particular demand and supply conditions affecting the spectrum concerned.

7.37 For packaging purposes in the DDR cleared award, we can distinguish the following key drivers of material value differences that are frequency-specific in the cleared spectrum:

- **The interleaved spectrum in channels 61 and 62**. As set out in our December statement, the key basis for including this interleaved spectrum within the DDR cleared award concerns its potentially distinct value (relative to other interleaved spectrum). This arises from the potential inclusion of these channels as part of a harmonised part of the band under the non-mandatory framework being developed by CEPT. Nevertheless, the prior existence of DTT transmissions in these channels will significantly constrain the deployment of other networks and hence significantly reduce their value relative to cleared parts of the spectrum.

- **Channels adjacent in frequency to existing DTT**. We proposed, in section 5, that licences in the DDR cleared award would include obligations to ensure that interference to existing DTT users was avoided. The impact of these obligations on licensees, and the impact of incoming DTT interference on licensees, is likely to be greatest for channels adjacent to DTT where the costs and types of network that will arise will potentially be different, and hence the values of the lots concerned will be frequency-specific.

- **Channels adjacent to channel 38**. While this channel will be cleared of radio astronomy ("RAS") in the UK during 2012, we expect that it will still be used for this purpose in neighbouring countries in continental Europe. The need to respect international obligations in respect of RAS will place specific restrictions on transmissions from both UK licensees using channel 38 and from licensees using frequency in the adjacent channels 37 and 39 in the UK, as described in section 5. The former will effectively preclude any medium-power network at national level, while the latter may have value consequences relative to other cleared DDR channels.

- **The early availability of channel 36**. As noted in section 4, channel 36 will be made available for UK-wide use immediately after the award in 2009, whereas the UK-wide availability of other channels will be constrained to DSO timetables. This materially increases the relative value of channel 36, other things being equal.

7.38 In addition to these channel-specific differences, there are three other more general sources of value variation by frequency within the cleared spectrum:

- **The international constraints of the GE-06 Plan**. This Plan was negotiated to facilitate international coordination of UHF Bands IV and V in Europe during digital switchover. The Plan is guiding the work of CEPT in defining the technical principles of coordination and non-mandatory harmonisation for those European countries with digital dividends. It reflects the locations of existing high-powered broadcasting transmitters operating at different frequencies in the different countries. As indicated in the work we published alongside our December Statement, this creates envelopes for both UK transmissions and incoming interference that vary according to the existing broadcasting channels. Because these international constraints vary by frequency within the band, the technical constraints that must be applied in the cleared-award licences for different frequencies will differ by frequency.

- **The constraints of the UK DSO programme**. The development of the UK's existing DTT platform during and beyond DSO is being guided by the specific

frequencies that have been allocated to the platform by the Government and by the use of these frequencies within the existing multi-frequency network configuration of DTT. The DSO plans seek to ensure that transmitters and relays in different parts of the country use different specific channels in particular aerial groups to optimise coverage without requiring receiver changes (such as roof top aerial repositioning) during DSO. Any use of the cleared spectrum for DTT purposes (e.g. to create additional UK-wide multiplexes) would require the selection of specific channels in order to deploy complementary networks on an efficient basis. These particular channel combinations will have additional value for such broadcasting applications.

- **The extent of harmonisation of the band at European level**. While there remains some debate in different European fora as to the relative benefits of market-driven or mandated/regulated spectrum harmonisation in the context of the digital dividend, as we discussed in section 3, there are clear scope and scale benefits to some users from having access to the same or similar frequencies across larger parts of Europe. This reduces the costs of equipment procurement, and in some cases makes the use of mobile technologies easier for users moving across European borders. Because terrestrial broadcasting arrangements are likely to be highly specific to different countries, as noted in the Commission's Digital Dividend Communication, particular value impacts of European harmonisation are likely to arise for mobile technologies above 790 MHz (i.e. within the upper sub-band in the DDR cleared award), which was designated in WRC-07 for co-primary broadcasting and communications use.

7.39 In the limit, these frequency-based sources of value variation would point to the option of a large number of completely frequency-specific lots – for example:

- Lots defined as fixed 8 MHz rasters which align to the existing broadcasting channel plan, on which the GE-06 arrangements were agreed; and

- Each and all of these channels (31, 32, etc) being defined as unique frequency-specific lots.

7.40 This is effectively the approach we adopted in the L-Band award, where every lot was defined on a mutually-exclusive, frequency-specific, basis. However enforcing only this level of specificity in defining lots for the DDR cleared award would preclude:

- The definition of 5 MHz lots, which as we noted above is the most likely basis of potential mobile communications deployments and harmonised band planning for communications applications in the band; and

- The definition of frequency-generic lots entirely, with instead the creation of a potentially very complex auction, with associated risks of efficiency losses, as discussed above.

7.41 Alternatively we could define all lots (by general TLC type) to be frequency-generic, along the lines of the proposed approach to the 2.6 GHz award. However in the DDR cleared award this would effectively ignore, at the outset of the auction process, the material sources of value variation by frequency of the form that that we have described above.

7.42 We therefore propose to adopt the hybrid approach to defining lots in terms of frequency, isolating what appear to be the most material sources of valuation in order

to create **lot categories** defined by frequency for the primary stage of a multi-stage auction, but then enabling bids to become fully frequency-specific in the final assignment stage. Effectively, this mirrors the general approach adopted in, for example, the 10-40 GHz award. It preserves frequency-generic lots where possible in some lot categories, but involves a number of frequency-specific lot categories as well.

7.43 On this basis, we have examined the likely sources of material value variation separately for each of the generic TLC types we defined in section 5, as some of these sources are TLC-specific, and developed outline lot category proposals accordingly. As noted above, some frequencies will acquire differential value only as a result of their being used in combination with others by a single successful bidder. Such contingent value impacts are best reflected in defining rules in relation to auction design, as discussed in section 8, and not in the specification of the initial lot categories in this section, where we focus instead on those frequency-based value differences which are largely independent of particular auction outcomes.

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

MMS TLC type

7.44 For the 8 MHz TLC types suitable for mobile multimedia broadcast services, the lots could have fixed-frequency rasters that adhere to the existing GE-06 channel planning, in line with our December 2006 consultation proposals. However while this could facilitate international and UK coordination for broadcasting in the frequencies concerned, it could potentially constrain efficient spectrum allocation outcomes for an award where 5 MHz lots suitable for two-way communications would not in any event be following the existing broadcasting channel plan. Our understanding is that users of the spectrum for MMS applications would not require adherence to the existing DTT channel plan, and would be able to use frequency more flexibly.

7.45 This flexibility would potentially allow a greater number of lots to be awarded, depending on the mix of lot types that emerged from the auction outcome. An illustration of this concept is provided in Figure 7.1 below. In this illustration an 8 MHz lot has been positioned adjacent to 5 MHz lots (and/or guard bands) within three existing 8 MHz broadcasting channels.

Figure 7.1 Potential deviation from existing broadcasting channel plan

7.46 On this basis we propose not to define MMS lots with respect to specific frequencies in general, although the existence of frequency-specific constraints (such as between channels 38 and 41) and the early availability of channel 36 would imply significant value differentials for some lots, which we would reflect in frequency-specific lot categories by exception.

7.47 On this basis, for the reasons identified above, the following single-lot categories would be identified for lots which (partially or wholly) occupied specific channels, for the differential value reasons shown in brackets:

- Wholly or partially in channel 31 (adjacent to existing DTT)

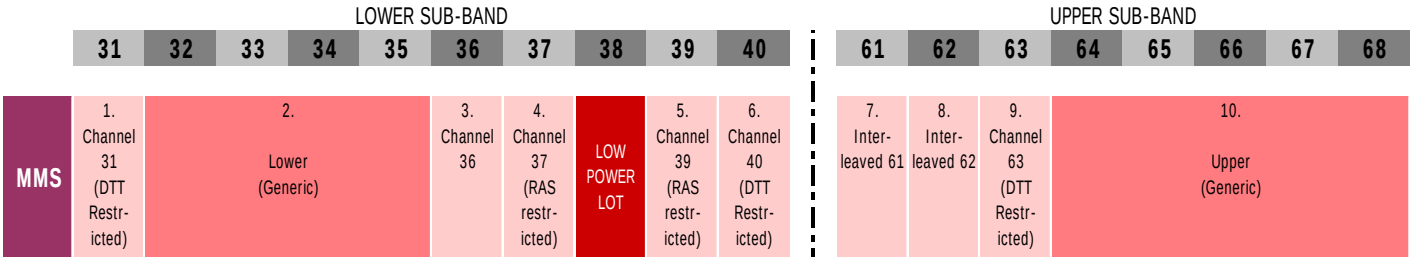
- Wholly in channel 36 (early UK-wide release)
- Wholly or partially in channel 37 (adjacent to RAS in channel 38)
- Wholly in channel 39 (adjacent to RAS in channel 38)
- Wholly in channel 40 (adjacent to existing DTT)
- Wholly in channel 61 (interleaved, with material geographic constraints in TLC)
- Wholly in channel 62 (interleaved, with different material geographic constraints in TLC)
- Wholly or partially in channel 63 (adjacent to existing DTT)

7.48 For licences with MMS TLCs, we propose that the remaining spectrum (mainly occupying frequencies in channels 32-35 and 64-68) is grouped into 8 MHz lots in two frequency-generic lot categories:

- one category of up to 4 lots for the lower sub-band spectrum (where the lots could be adjacent to, and hence potentially contiguous with, channel 36, where significant interest has been expressed from potential mobile broadcasters); and
- one category of up to 5 lots for the upper sub-band spectrum (where any European harmonisation for mobile communications purposes is most likely to emerge).

7.49 This categorisation is illustrated in Figure 7.2 below. It implies a judgement that the different geographic constraints on the national channels arising from GE-06 Plan and UK DSO for channels 32-35 and 64-68, while significant, are not sufficiently material to undermine their partial substitutability as frequency-generic lots for MMS type applications in the primary stage of a multi-round auction, *provided* bidders then have an opportunity to specify the exact combination of frequencies they prefer. For example, international restrictions may also increase the cost of transmission involving the use of frequency in channel 67 in the south east of England, but such costs could be mitigated, potentially by the use of frequency in the channel in conjunction with frequency in one or more other specific channels.

Figure 7.2 MMS lot categories



The actual frequency location of the restricted lot categories shown in channels 31 and 63 would not be fixed in practice; the figure shows a possible outcome.

7.50 The categorisation also implies an assumption that international restrictions arising from the GE-06 Plan will not materially affect the relative value of lots partially occupying these channels (in comparison with channels 64-66) for MMS use. Was

this assumption to prove inappropriate, additional MMS lot categories might need to be specified.

DVB-T TLC type

7.51 For the TLC type suitable for terrestrial broadcasting with technologies such as DTT, we propose defining lots as 8 MHz fixed-frequency rasters, based on the existing broadcasting channel plan, as it is reflected in the GE-06 Plan. In addition to facilitating the process of international coordination according to this channel plan, fixed-frequency rasters would also facilitate the coordination of new services with existing DTT services based on the existing "high power, high tower" UK transmission network.

7.52 As with the licences suitable for MMS, different channels have different geographic restrictions imposed by the GE-06 interference envelopes. However these impacts were allowed for in the GE-06 process and can in part be addressed by the assembly of multi-channel spectrum packages of complementary lots. In this context, it is possible that particular GE-06 impacts would not necessarily dominate in driving value differences between channels.

7.53 Instead, apart from the restrictions arising from international coordination, a more important driver of value by frequency for DTT-suitable licence types used in a multi-frequency network environment is likely to be the aerial group[44] already supported by the channel. The more aerial groups that are supported, the more flexibly the channel can be used as part of a multi-frequency network (e.g. to support an additional DTT multiplex) and hence the more efficiently spectrum can be used in network terms.

7.54 On this basis, the DTT aerial groups supported by the cleared channels is as shown in Table 7.1:

Table 7.1 Existing aerial groups of channels

Channel	*Aerial groups*
31-34	A
35-37	A and B
39-40	B
61-68	C and D

7.55 It can be seen that channels 35-37 and 61-68 support more than one aerial group and hence are capable of being used more flexibly (typically in conjunction with other channels) in a multi-frequency network.

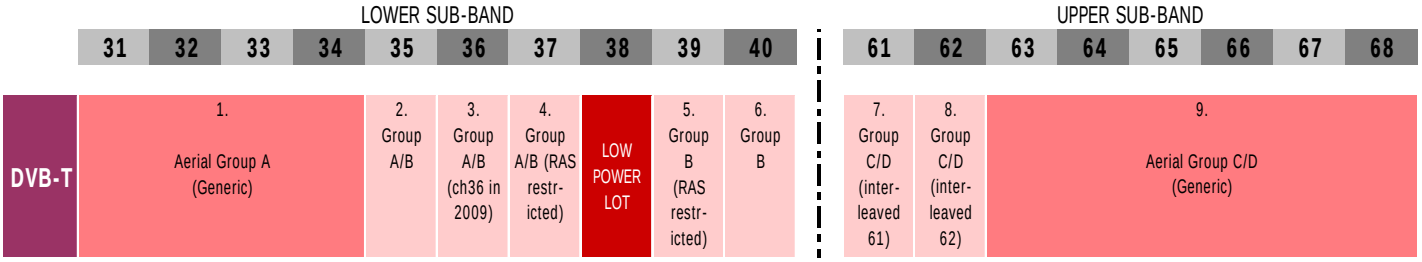
[44] TV aerials are less efficient if they have to cover the whole of the of the UHF TV spectrum. To maximise reception efficiency TV services are generally grouped into a segment of the band such that receive aerials can optimise their efficiency. Aerials are categorised into 3 main groups, A, B and C/D as follows: A: ch21 – 37; B Ch35 – 53 and C/D Ch 48 – 68.

7.56 Accordingly we propose to designate:

- Channel 35 as an additional single-lot category for DVB-T TLC types (i.e. distinct from channels 31-34)
- Channel 36 as a distinct single-lot category (due to its early availability)
- Channels 37 and 39 as two distinct single-lot categories (due to their specific international constraints associated with international RAS)
- Channel 40, which only support aerial group B and again could therefore have distinct value, as a distinct single-lot category
- Channels 61 and 62, each of which represents interleaved spectrum in different geographic areas, as two distinct single-lot categories

7.57 Other channels can potentially be identified as generic lots – 31-34 supporting only aerial group A (four lots), and 63-68 supporting aerial groups C and D (six lots). As with the MMS TLC types discussed above, this categorisation (illustrated in Figure 7.3 below) implies an assumption that international restrictions arising from GE-06 will not materially affect the relative value of lots occupying these channels (in comparison with channels 64-66) for DVB-T use. Was this assumption to prove inappropriate, additional lot categories might need to be specified.

Figure 7.3 DVB-T lot categories



TDD TLC type

7.58 For the TLC type suitable for TDD, the need for large (16 MHz) guard bands between TDD and DTT frequencies, as set out in section 5, would effectively preclude the economic deployment of a TDD network using the frequency in channels 39 and 40. As noted in section 5, because TDD mobile transmissions are geographically variable and unpredictable, such guard bands are needed to protect DTT licensees from incoming interference.

7.59 While guard bands of this size are unlikely to be needed to protect radio astronomy (in channel 38), the additional constraints that could affect the values of any relevant TDD licences in frequencies which are adjacent to these channels could be material if constraints persist beyond 2012. As explained in section 5, we have assumed this will be the case for the protection of international radioastonomy in channel 38.

7.60 In section 5 we outlined our proposals to address the risk of base-station to base-station interference that might occur between different FDD and TDD licensees. We proposed that a guard-band of 5 MHz is required at frequency boundaries which separate FDD and TDD blocks, or at those which separate different licensees of TDD spectrum. This guard-band would allow technologically viable mitigation of base-

station to base-station interference via transmit and receive filtering. This proposal implies that different TDD lots may have differing TLCs, depending what services they are adjacent to in spectrum terms.

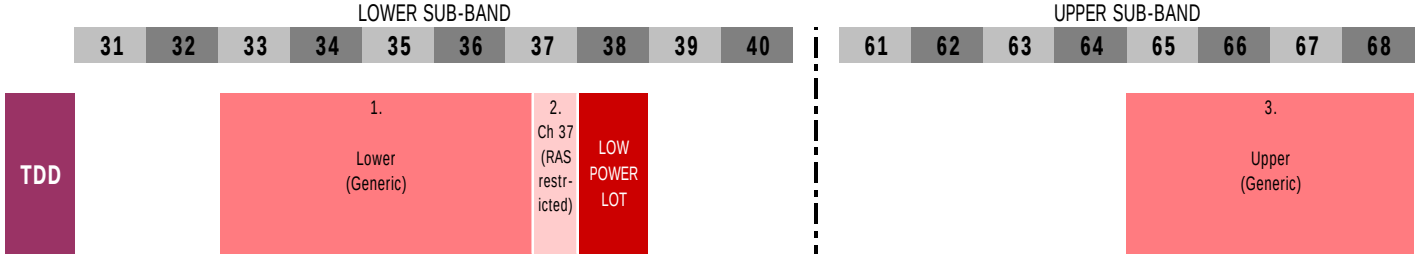
7.61 Consistent with our reasoning in the 2.6 GHz award we assume here that the cost of the required filtering (above and beyond that implemented today in 3G base stations) would be a small percentage of the total cost of base station equipment, even for multiple transmit and receiver branches per sector. Therefore, although some TDD licences may have somewhat different TLCs to others (depending upon what services are in adjacent frequency channels) no lot would imply that the successful licensee required network equipment that is substantially more expensive than others. Accordingly we do not propose to create a distinct lot category for "boundary" TDD lots in the multi-round stage of an auction.

7.62 Finally, given the potential for the upper sub-band to be harmonised for mobile communications purposes at the European level, it is plausible that frequency in this sub-band would become materially more valuable than frequencies in the lower sub-band, from the perspective of prospective licensees seeking to deploy TDD technologies in the frequencies concerned.

7.63 Accordingly, we propose that three lot categories are defined for TDD type TLCs as illustrated in Figure 7.4 below:

- A one-lot category for TDD using frequency within 5 MHz of channel 38;
- A frequency-generic category for up to seven 5 MHz lots[45] in the lower sub-band; and
- A frequency-generic category for up to six 5 MHz lots in the upper sub-band.

Figure 7.4 TDD lot categories



The actual frequency location of the restricted lot category shown in channel 37 would not be fixed in practice; the figure shows a possible outcome.

7.64 It should be noted that the frequency locations of the generic lots would not be fixed during the initial stage of a multi-round auction, because 5 MHz frequencies do not align to the existing GE-06 channel plan and the exact frequency locations would need to be determined when the balance between any 8 MHz and 5 MHz licences was known as an outcome of the relevant stage of the auction. Nevertheless there would still be opportunities for bidders to express preferences for specific frequency locations in subsequent stages of the auction.

7.65 The other implication of this packaging format of frequency-generic lots is that the size of the guard bands between TDD and existing uses could (depending on the arrangement of any 8 MHz lots in the band following the auction) be higher than the

[45] Assuming 5 MHz is defined as the standard TDD lot size.

minimum specified (e.g. more than 5 MHz between TDD and FDD). This is because the available spectrum in the two sub-bands is not exactly divisible by 5 MHz.

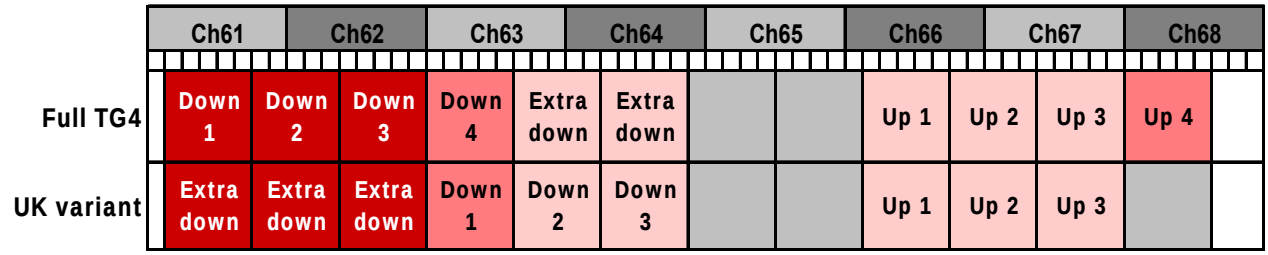
7.66 The alternative would be to define a series of frequency-specific lots, of varying non-standard bandwidths, which would only be available contingent on certain band plan outcomes of the auction. We do not consider such an approach would add significantly to spectrum efficiency, while it would add very significantly to the complexity of the auction by creating a large number of possible contingent combinations of bid packages. Instead therefore we propose to develop auction rules to deal with the potential emergence of larger guard bands as auction outcomes, as described in section 8.

FDD TLC type

7.67 For the TLC type suitable for FDD, we have adopted, at this stage, a working assumption that features of the harmonised European band planning work that has so far been undertaken in CEPT for the upper sub-band can be reflected in the cleared-award packaging. However, in making this assumption, we consider that it could be important (as with the 2.6 GHz award) to preserve the flexibility in the auction to depart from any fixed-frequency rasters that might be reflected in the CEPT non-mandatory planning, should market demand as expressed in the auction indicate the desirability of this outcome.

7.68 CEPT explored a plan for FDD type use in the upper sub-band that involves fixed-frequency 5 MHz rasters and a 40 MHz duplex separation, in discharging its first Mandate from the Radio Spectrum Committee ("RSC") of the EU. However, a key reason why the RSC has argued for CEPT to develop such planning for the upper sub-band on a non-mandatory basis at the European level is that a number of affected EU countries, including the UK, will continue to have broadcasting uses for parts (in some countries, all) of this sub-band after DSO, while non-FDD technologies may also need to be accommodated in future spectrum allocation decisions. Reducing the 40 MHz duplex spacing in the CEPT plan to 25 MHz in the UK, but retaining the same fixed-frequency 5 MHz rasters, would for example permit three paired lots to be defined entirely within cleared spectrum for the upper sub-band, as illustrated in Figure 7.5 below:

Figure 7.5 Potential arrangements of FDD lots in upper sub-band



7.69 An even greater number of paired FDD lots (and/or mixes of other technologies) could be accommodated if the fixed-frequency 5 MHz rasters were replaced by variable-frequency 5 MHz rasters, while still retaining some features of the harmonised European band planning work via auction rules, along the lines of the approach adopted for the 2.6 GHz award. The following auction rules are suggested as a possible basis to award FDD uplink licences across a given sub-band in the UK on a more flexible basis in this way:

- Will always be paired with equivalent downlink licences;
- Paired downlink licences would have a duplex spacing of at least 25 MHz; and
- All uplink licences would be positioned at least 10 MHz higher than the highest FDD downlink or TDD licence (except FDD downlink in channels 39 and 40).

7.70 It is unlikely to be feasible to design an auction which simultaneously accommodates a wide variety of alternative such packaging rules. However for FDD in the upper sub-band, it may in principle be possible to offer the market (via the auction) a direct choice between a smaller number of lots which are aligned to the potential shape of a harmonised non-mandatory European plan, and a larger number of frequency-generic lots which would not be guaranteed to be in exact alignment with such a harmonised plan. This would be achieved by creating distinct lot categories for each version, so that the feasible combination of lots of different types (FDD with fixed-frequency rasters, FDD with variable-frequency rasters, and other TLC types) with highest aggregate value in the auction was the outcome in the award.

7.71 As with TDD lots, FDD uplink lots would be precluded from channels 39 and 40 by the need for a guard-band between DTT, and the TLC for the licence assigned below channel 38 (say within 5 MHz) would require constraints to protect international radio astronomy.

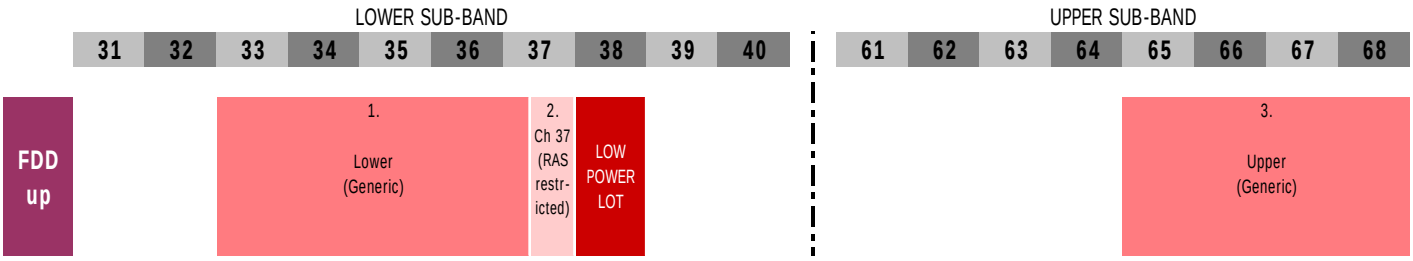
7.72 As with TDD lots, FDD downlink licences may have differing TLCs, depending what services they are adjacent to in spectrum terms in order to address potential base-station to base-station interference. Our assumption in the case of FDD downlink is in line with the TDD assumption that, although some FDD downlink licences may have different TLCs to others (depending upon what services are in adjacent frequency channels in the band plan that emerges from the auction) no licensee will require network equipment that is substantially more expensive than others, and hence we have not proposed a distinct lot category for the "boundary" lots concerned.

7.73 The application of the above location rules and lot definitions would then imply a total of three lot categories for FDD 5 MHz uplink licences without fixed-frequency rasters in the upper sub-band, as illustrated in Figure 7.6 below:

- A one-lot category for FDD uplink using frequency within 5 MHz of channel 38;
- A frequency-generic category for up to seven 5 MHz lots[46] in the lower sub-band; and
- A frequency-generic category for up to six 5 MHz lots in the upper sub-band.

[46] Assuming 5 MHz is defined as the standard FDD lot size.

Figure 7.6 FDD uplink lot categories



The actual frequency location of the restricted lot category shown in channel 37 would not be fixed in practice; the figure shows a possible outcome.

7.74 However, if fixed-frequency rasters in the upper sub-band, in line with a European harmonised band plan, were also to be offered as distinct lot categories as described above, this would imply an additional frequency-generic category for "aligned" 5 MHz uplink lots in the upper sub-band.

7.75 Finally, FDD downlink lots in consistent categories would be implied by the same principles as discussed above for FDD uplink licences. However, in addition, account also needs to be taken of the opportunity to define additional downlink licences in the spectrum that is adjacent to existing DTT in the cleared channels 31, 39-40, and 63, and interleaved with existing DTT in channels 61 and 62. This is because the relevant downlink transmitters in such FDD networks would be in fixed geographic locations, so that the proposed flexible licence obligations to protect existing DTT users can be imposed, as explained in section 5.

7.76 These obligations, in conjunction with the more limited geographic availability of spectrum in the channel 61 and 62 frequencies, and the lower value of unpaired downlink-only lots, would mean that the values of these lots could be significantly different from other FDD downlink lots, and from each other.

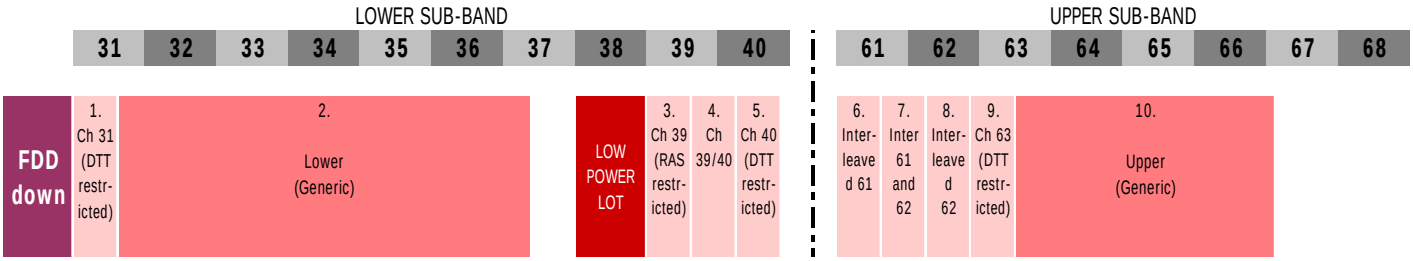
7.77 This implies the following lot categories for the FDD downlink licences without fixed-frequency rasters as illustrated in Figure 7.7 below:

- A one-lot category for the licence using frequencies within 5 MHz of DTT in channel 30 (particularly affected by the interference protection obligations)
- Three one-lot categories for the three licences[47] that would be possible in channels 39 and 40 (adjacent to channel 38, adjacent to channel 41, and the intervening 5 MHz licence). All three could be defined to be paired with uplink licences located in the lower sub-band if required;
- Three one-lot categories for the three licences that would be possible within the interleaved spectrum in channels 61 and 62 – wholly within channel 61, wholly within channel 62 and spanning channels 61 and 62 (with the differing geographic constraints applicable in each case rendering each a distinct lot category);
- A further one-lot category for the licence within 5 MHz of DTT in channel 62 (particularly affected by the interference protection obligations)
- A frequency-generic category for up to nine 5 MHz lots in the lower sub-band; and

[47] Assuming 5 MHz is defined as the standard FDD lot size.

- A frequency-generic category for up to five 5 MHz lots in the upper sub-band.

Figure 7.7 FDD downlink lot categories



The actual frequency location of the restricted lot categories shown in channels 31 and 63 would not be fixed in practice; the figure shows a possible outcome.

7.78 A one-lot category for a FDD downlink licence using frequencies within 5 MHz of RAS in channel 38 (affected by the relevant interference protection obligations) could also in principle be defined. In practice however, such a licence could only be awarded if no FDD uplink licences were awarded at all in the lower sub-band. We consider this to be a very unlikely outcome and therefore do not propose to create a specific lot category for such an outcome.

7.79 Again, as with the FDD uplink licences, if fixed-frequency rasters in the upper sub-band, in line with the CEPT initial proposed band plan, were also to be offered as distinct lot categories in the auction, this would imply an additional four single-lot categories (for the three licences occupying interleaved spectrum and that adjacent to channel 62) and an additional frequency-generic category for 5 MHz lots in the upper sub-band.

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

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

Channel 38

7.80 As noted in section 5, the current use of channel 38 for international radio astronomy would severely limit UK transmission at any significant power in this frequency (while clearing this channel of radio astronomy use in the UK during 2012 would alleviate constraints on the adjacent channels in Great Britain, and in the channel itself in Northern Ireland). The channel would hence have its own unique constraints, reflected in the relevant licence conditions, and would constitute a single 8 MHz lot for auction purposes.

7.81 There are two approaches which could be adopted in awarding channel 38 as a distinct lot. Firstly we could simply award the lot with a specific set of TLCs which restrict usage in the UK to that consistent with domestic obligations until 2012 and international obligations on an enduring basis. As discussed in section 5 we think there is a risk of setting low power national TLCs which could be overly restrictive whilst international obligations remain. Furthermore these TLCs would require revision were deployment of higher power services desired in the event that international protection obligations were eased, potentially adding regulatory uncertainty.

7.82 A second approach would be to award channel 38 with the standard TLC set out in section 5 for each of the generic network types considered – FDD, TDD, DTT and MMS. This approach has the advantage that there is little risk of the TLCs being overly restrictive and TLCs may also be appropriate for subsequent high power services in the event of eased international emission restrictions. This could potentially entail up to a further 5 lot categories being required. However we note that in practice the licences would be limited to very much lower emission levels than implied in the licence TLCs, due to the international protection obligations also within the licence. We believe that the restrictions enforced by the international protection obligations are likely to dominate the value of the spectrum, rather than the national TLCs. Therefore we believe that a single lot category may be appropriate for award of channel 38, but that the TLCs ascribed to the awarded lot are those appropriate to the purchaser.

7.83 In either approach, as we have noted in section 5, we propose that restrictions would need to apply to prevent transmissions from channel 38 interfering with neighbouring services in channels 37 and 39. This could be achieved through use of a coordination agreement between the interested parties. This is discussed further in section 5.

7.84 The latter approach seems to be less restrictive and to offer increased regulatory certainty in the even that international obligations are eased. These benefits can be accrued with no additional complexity to the award process if one lot is used for the award of channel 38, which we believe is reasonable since, in the near term, international protection obligations present severe restrictions on the usage which may be made of the spectrum. Therefore we propose to award channel 38 as a distinct 8 MHz lot. The lot may have one of the 5 standard technical licence conditions proposed for other channels of the DDR cleared award, based on the 5 standard TLCs given in Annex 10.

7.85 To implement this approach in our proposed auction for the cleared DDR award, the winning bidder that obtained channel 38 as part of its winning package bid in the auction would simply identify which of the five available sets of technical licence conditions they wished to have before being awarded the licence concerned; no further bids would be required once the winning bidder had been determined.

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

Summary of lot categories defined by frequency

7.86 Drawing the above discussion together, Table 7.2 below summarises our proposals for the lot categories, and numbers of lots in each category, for each generic TLC type in the band:

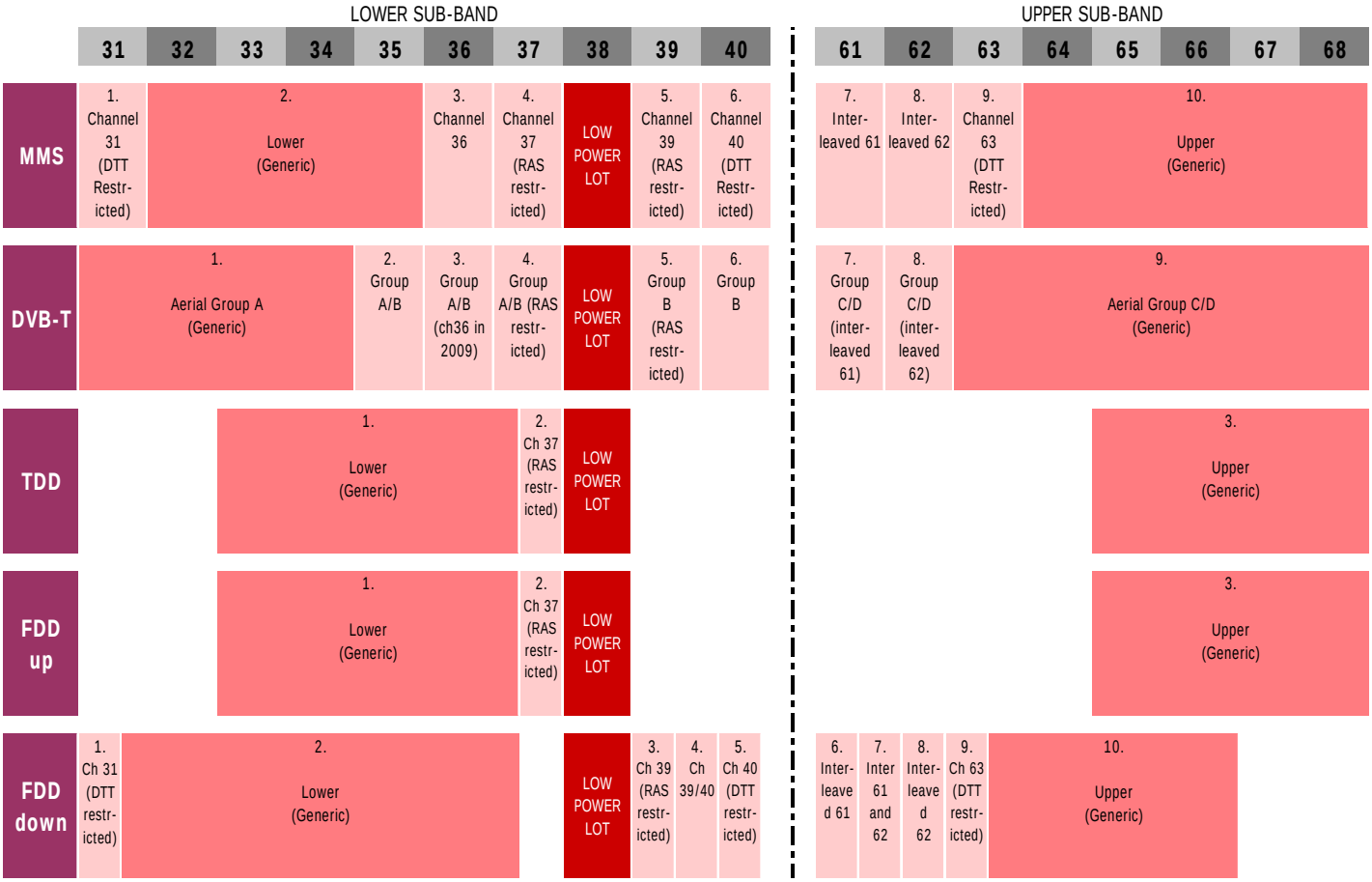
Table 7.2 Summary of proposed lot categories

	TLC type	DTT	MMS	TDD	FDD up	FDD up	FDD down	FDD down	Low power
	Lot size (MHz)	8	8	5	5	5	5	5	8
	Fixed-frequency raster	Yes	Some	No	No	Yes: upper	No	Yes: upper	Yes
Lot	Channel 31		1						
	Channel 35	1							
	Channel 36	1	1						

Channel 37	1	1						
Channel 38								1
Channel 39	1	1						
Channel 40	1	1						
Channel 61	1	1						
Channel 62	1	1						
Channel 63		1						
Adjacent to Channel 30						1		
Adjacent to Channel 38			1	1				
Within Channel 39						1		
Across Channels 39 & 40						1		
Within channel 40						1		
Other Lower sub-band	4	4	7	7		9		
Within channel 61						1	1	
Across channels 61 & 62						1	1	
Within channel 62						1	1	
Adjacent to channel 62						1	1	
Other Upper sub-band	6	5	6	6	4	5	2	
Total lot categories	**9**	**10**	**3**	**3**	**1**	**10**	**5**	**1**

7.87 In schematic form these lot-types can be visualised according to Figure 7.8 below.

Figure 7.8 Summary of lot categories proposed



The actual frequency location of some of the restricted lot categories would not be fixed in practice; the figure shows possible outcomes.

7.88 It can be seen that a large number of lot categories have been defined in total - around 35, even without the additional option of fixed-frequency rasters for FDD type licences in the upper sub-band. In each case, the variations have been proposed based on potentially material value differences arising from different frequencies. Although bidders for particular types of licence would need to focus on a smaller number of lot categories, the total number of categories is large, and there are some options for simplifying this packaging for the purposes of auction design, as further discussed in section 8.

Packaging outcomes

Key considerations

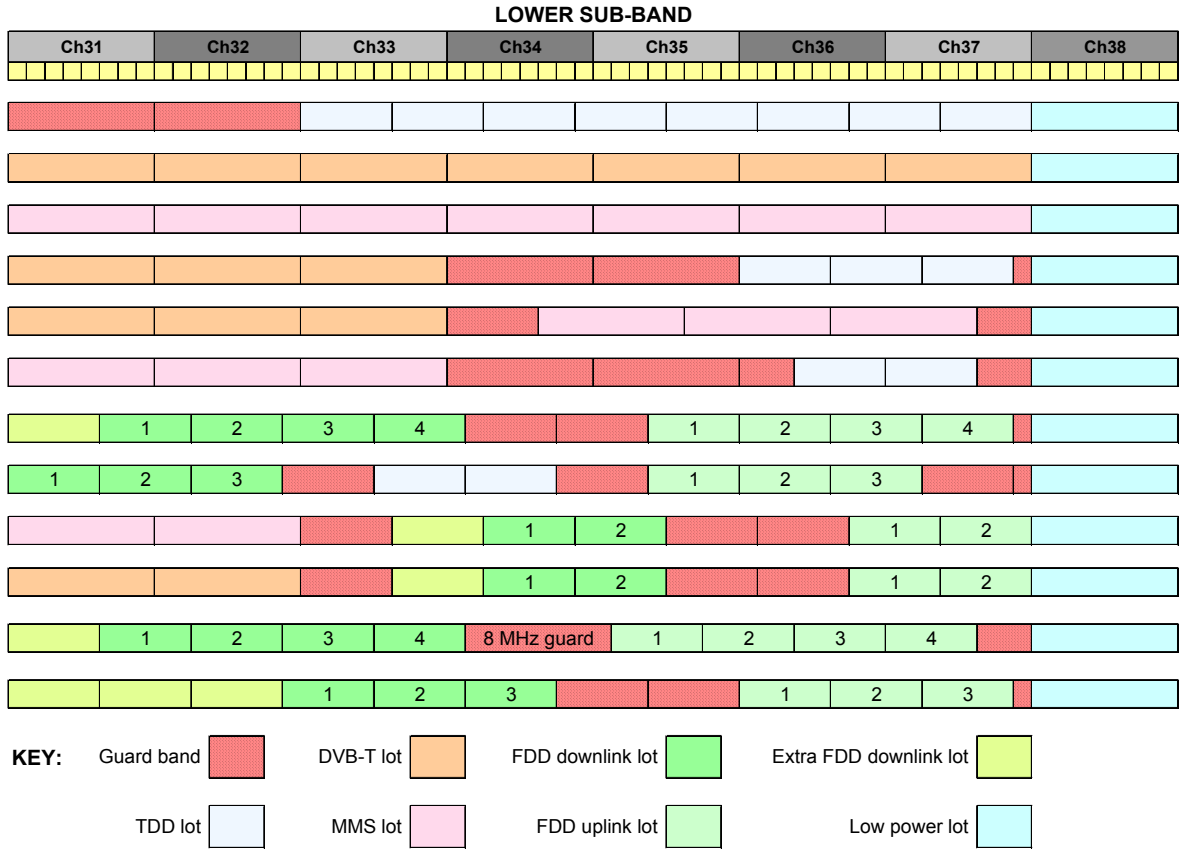
7.89 Under our proposals for the DDR cleared award there will be five technology-neutral types of TLCs (whether of transit masks or SUR) included in variants of the licences to be awarded. These will be tailored to the five types of transmissions expected by services likely to use the DDR cleared spectrum, as described in section 5 above. The different licence types emerging as neighbours, as a result of the preferences expressed through the auction process, will have a guard band separating them as required, as set out in section 5. The sizes of these guard bands will depend upon the nature of the licences in the neighbouring frequencies - the separation required to give each licensee adequate protection from interference arising from their neighbours' transmissions. This mixture of different licence types and different guard

bands separating them leads to very many possible band-plans that might emerge as a result of the award process.

7.90 This very large number of possible outcomes is a key challenge for efficient auction design, as discussed in section 8. Equally however there may be many conceptually possible band-plan outcomes which are in practice undesirable from a technical and commercial perspective in any event. For example, we must ensure that FDD uplink licences are paired with FDD downlink licences in the resulting band-plan in a suitable configuration in order to render them useful for the successful bidder concerned. Nevertheless, even taking into account plausible constraints on outcomes that are enforced via auction rules to ensure their technical and commercial viability, there may still be a great number of possible viable outcomes.

7.91 Figure 7.9 illustrates, for example, some of the possible band-plan options for channels 31-38 in the lower sub-band that could emerge by distributing the different licence types, and required guard bands between them, in different ways across the spectrum available. Other variants exist, for example involving different relative numbers of the lots shown.

Figure 7.9 Selection of illustrative potential band-plan outcomes for the lower sub-band



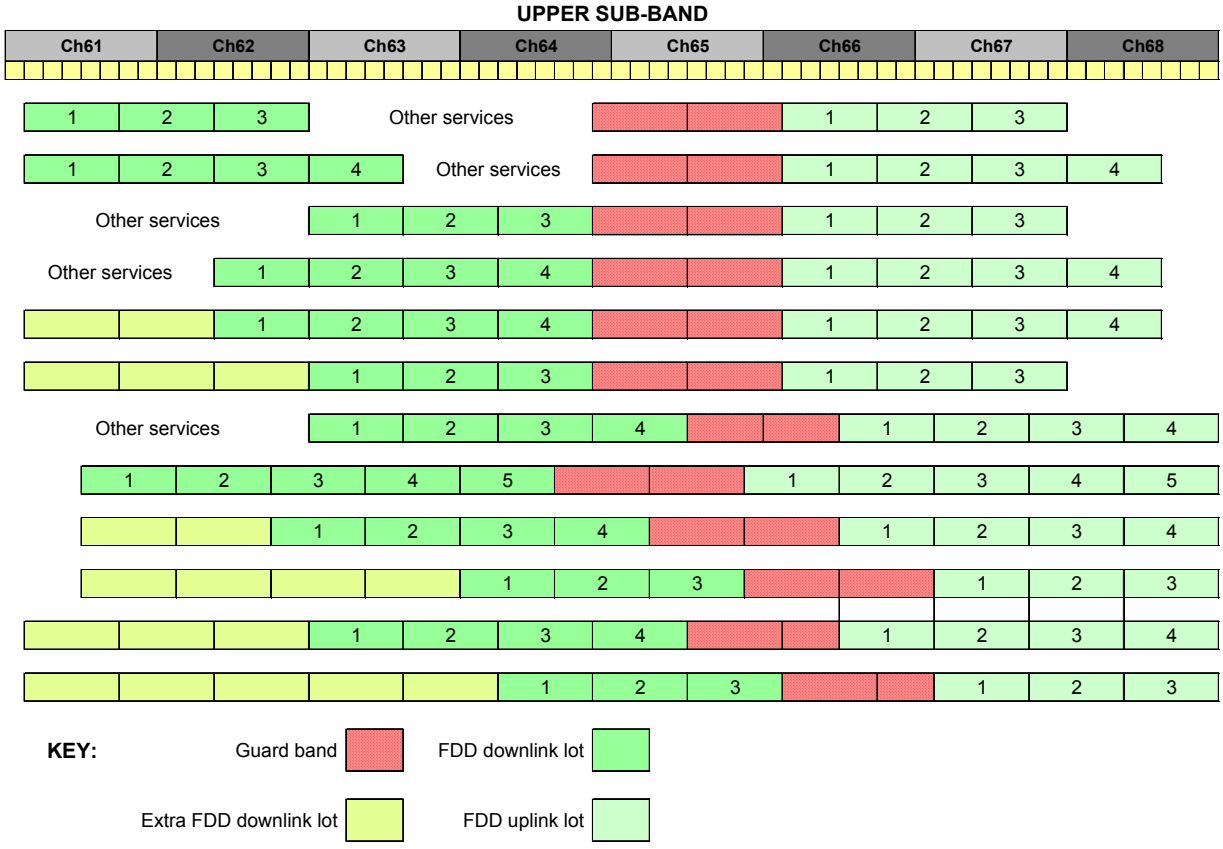
7.92 Different variant-sets of outcomes also exist for other parts of the available spectrum. We discussed earlier in this section (paragraphs 7.67 to 7.79) some of the considerations determining how FDD licences could be distributed within the spectrum, with particular reference to the upper sub-band. Again, a large number of

potential band-plan outcomes could arise from the award of the spectrum, depending upon a range of considerations such as:

- Number of paired versus unpaired channels defined for award
- Symmetric versus asymmetric bandwidth services
- The degree of alignment with harmonised European band-plans
- Duplex spacing
- Guard-band separation of uplink and downlink channels.

7.93 Accordingly, such considerations can again lead to a potentially very large number of potential band-plans. Figure 7.10 shows some band-plan examples for FDD in the upper sub-band which illustrate this point.

Figure 7.10 Selection of illustrative potential band-plan outcomes for the upper sub-band



7.94 These examples illustrate that there are a very large number of such permutations across the whole of the available spectrum. Given this, one means by which a practicable auction process could be constructed would be for us to pre-define a much smaller number of band-plans which are allowed, and to develop auction rules which specified in advance that lots would always be constituents of one of these band-plans as an outcome of the award. Such rules would need to reflect those

band-plans that were considered most likely to emerge, in consultation with stakeholders.

7.95 However we consider that this route could potentially be overly restrictive, and hence increase the risk of inefficient spectrum allocation, given that we are unlikely to be able to predict with confidence the "most likely" consolidated band-plans which may result. This is because of a combination of the very large number of permutations available, and the uncertainties affecting demand for the spectrum for different uses. In this environment, we do not consider ourselves best placed to make such specific market-based pre-judgements, even with stakeholder input, and rather would prefer to develop an auction design in which the market was able to reveal preferences through an iterative bidding process.

7.96 Nevertheless it is unlikely that complete flexibility in lot allocation, to support all the theoretically possible outcomes in the award, is either feasible or desirable from a bidder perspective. For example, of the different options for organising FDD assignments within the final band-plan, it seems likely that only a limited number of variants can be simultaneously reflected in the auction design process and we would welcome views from respondents to this consultation as to which should be reflected.

7.97 Another possible means by which the number of possible band-plan outcomes could be reduced would be to split the award of the cleared spectrum into more than one smaller award. For example there could be separate awards of the lower and upper sub-bands. This would significantly reduce the total number of permutations that are possible when both sub-bands are considered together in a larger award. However some bidders may wish to purchase spectrum across the two sub-bands, and the success of the service they wish to deploy may be contingent upon this, so that the values of lots in different sub-bands are highly complementary and interdependent for the bidders concerned. For example, provision of a UK-wide multiplex using DVB-T technology in a MFN may require spectrum from both the upper and lower sub-bands.

7.98 In other cases, lots in the two sub-bands may be close substitutes, so that a bidder may require the flexibility to adjust demand for lots in different sub-bands according to their respective emerging opportunity costs, as revealed in a multi-round auction process. Splitting the DDR cleared award into the sequential auction of the two sub-bands could accordingly add significant uncertainty for such bidders, and make inefficient spectrum allocations more likely. For this reason we consider that it is not a desirable approach to follow, if alternative routes to facilitating efficient band-plan outcomes across the whole band can be found.

Frequency rules and basis

7.99 As noted above, while we do not think it appropriate to restrict the permitted band-plans that would be allowed as an outcome of the auction, some rules as to the distribution of awarded lots in the final band-plan could facilitate a simpler and more effective auction and guarantee bidders spectrum allocations that will be technically viable and hence which are likely to be commercially viable. We discuss the potentially appropriate rules for the DDR cleared award in this sub-section drawing together the considerations and proposals discussed earlier in this section.

7.100 Our proposed rules are generally intended to be the minimum required to ensure that the award outcome, in terms of the relative frequency location of licences, is both technically viable and realistic in commercial terms. At this stage our proposals reflect a working assumption that features of the harmonised European band

planning work undertaken by CEPT for the upper sub-band should be reflected. Our current proposals are that:

- As set out in paragraph 7.51, all DVB-T lots will be aligned to a fixed 8 MHz raster with the first lot starting in channel 31, as broadcasting is coordinated on this basis in the GE-06 Plan;

- MMS lots in channels 39, 40, 61 and 62 will be aligned to the DVB-T rasters, as set out in paragraph 7.47, as the restricted spectrum available in these channels would potentially make more flexible frequency assignment inefficient;

- All other lots will be aligned to a 1 MHz raster, as MMS, FDD and TDD users may not require exact adherence to the existing broadcasting channel plan and the flexibility implied by a 1 MHz raster will increase the options for auction outcomes which represent the most efficient use of the spectrum available;

- The guard-bands outlined in section 5 will be respected across all the available spectrum, and FDD uplink and TDD lots will accordingly be excluded from channels 39 and 40 as explained in paragraphs 7.58 and 7.71, as the guard band between TDD and DTT (in channel 41) is the same size as the spectrum available in these two channels;

- FDD downlink and uplink licences will be separated by at least 10 MHz in line with the initial band planning undertaken by CEPT for this band as explained in paragraph 7.69;

- As proposed in paragraph 7.69, all FDD uplink licences will be paired with a FDD downlink licence and separated by at least 25 MHz from it, with FDD uplink licences always at higher frequency, except for those paired with FDD downlink licences in channels 39 and 40 where a reverse pairing will be allowed if specified at auction. The proposed duplex spacing would permit a larger number of paired assignments in the constrained upper sub-band than the 40 MHz assumed in the initial CEPT band planning work, while the reverse pairing enables the potential use of channels 39 and 40 to support FDD-type applications if required.

7.101 As discussed above, the RSC has Mandated CEPT to undertake further work on non-mandatory, non-exclusive harmonisation of channels 61-69 for two-way mobile communications. Where relevant we will incorporate additional outputs from CEPT before our award, in our final proposed auction rules. This reflects a similar approach that has been adopted to the design of the 2.6 GHz award.

7.102 Additionally other auction rules could be applied to further restrict the possible band-plan combinations which would be permitted to emerge from the auction process. These could be based on ensuring greater technical efficiency (for example ruling out band-plan options with significant guard-bands) or based on demand: for example, alignment of FDD channels may be desired to a particular, say, 5 MHz raster that is pre-defined in the lower sub-band.

7.103 At this stage however we have proposed no such additional rules because the proposed auction format, as set out in section 8, is designed to enable the market to identify the combination of bids that collectively generates the highest value use of the spectrum, regardless of its apparent technical efficiency. For example the frequency adjacency of FDD uplink transmissions to DTT might require a large guard-band, but should not be precluded in advance.

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

Geographic coverage of licences

Background

7.104 In our Spectrum Framework Review[48], we said that in general, our preference would be for UK-wide licences unless there was a strong indication that the market would prefer licences with a smaller coverage. In the Spectrum Framework Review: Implementation Plan, we did not make any proposal on the geographic scope of licences for the digital dividend. Instead we deferred our consideration of policy options on this issue until we had achieved clarity on the extent of international constraints through the 2006 Regional Radio Conference (RRC).

7.105 In our December 2006 DDR Consultation, we set out our initial view that cleared spectrum should be offered on a UK-wide basis. In response to the Consultation, there was relatively little feedback on this proposal, with only 10 out of 750 respondents specifically commenting on the issue of UK-wide versus smaller lots. Of these, a small number specifically stated their support for UK-wide lots while a similar number preferred lots of a size suitable for Local TV. Another small group of respondents favoured splitting the spectrum into nation lots, i.e. Wales, Scotland and Northern Ireland lots. For example, our Advisory Committee for Northern Ireland (ACNI) suggested that a separate approach might be needed for Northern Ireland given a potential lack of bidders and all Ireland spectrum issues.

7.106 In our December 2007 Statement we restated our preference for UK-wide licences for the cleared digital dividend spectrum, while noting that we were discussing our proposals with the Irish authorities. We identified the interleaved spectrum as being particularly suited for services such as Local TV and decided to award separate geographic packages of interleaved spectrum on this basis. Our detailed proposals for these awards are set out in a separate Consultation document to be published shortly. In the remainder of this sub-section we review the case for UK-wide packages for the cleared spectrum.

Rationale for UK-wide lots and Northern Ireland issues

7.107 A key reason underpinning our general preference for awarding UK-wide licences for cleared spectrum relates to spectrum efficiency. In general it is more spectrally efficient to allocate spectrum across the UK as a whole rather than via licences with smaller geographic coverage. This is due to the need to leave spectrum unused between different services deployed in different geographic regions within the same frequency band, in order to avoid harmful interference. In contrast, an operator offering the same services across the UK would not need to leave any such gaps in its coverage and so would be able to use the available spectrum more efficiently, and hence offer a more comprehensive service to UK citizens and consumers.

7.108 While these arguments are also true in the case of Northern Ireland, the province has a number of unique features which make them less strong in this particular case. Northern Ireland is different from other parts of the UK in spectrum terms – on the one hand in that it shares a land border with the Republic of Ireland, while on the

[48] http://www.ofcom.org.uk/consult/condocs/sfr/sfr2/

other hand it does not share a land border with the rest of the UK. This means that, purely in terms of spectrum efficiency, the international coordination of services using the same frequency between Northern Ireland and the Republic of Ireland is potentially more significant than coordination between Northern Ireland and the rest of the UK (and than coordination between UK and other neighbouring countries, which are separated from it by the sea).

7.109 Additionally, under the GE-06 Plan, there is a limited number of assignments of cleared spectrum in Northern Ireland. On some of the channels in the UK's cleared spectrum, Northern Ireland has no internationally-agreed assignments under GE-06, whereas the Republic of Ireland has broadcast assignments that permit it to export high levels of interference into Northern Ireland. Without further bilateral coordination with the Republic of Ireland, it would be difficult to roll out new services on such channels in Northern Ireland, particularly in areas close to the border between Northern Ireland and the Republic of Ireland. Without further international coordination, it would also be difficult to deploy "high power, high tower" services (such as DTT) on these channels in Northern Ireland without breaching the internationally-agreed outgoing interference levels.

7.110 However, these factors need to be weighed against the fact that the release of spectrum on a UK-wide basis enables providers to offer services on a UK-wide basis more readily, and enables consumers to access those services accordingly. This is evident in for example the mobile services sector (where consumers in Northern Ireland can access services from the five UK-licensed mobile network operators) and the terrestrial broadcasting sector (where again consumers in Northern Ireland can access services provided by UK-wide providers).

7.111 We consider below the issue of evidence as to the demand for access to spectrum in this context, and the related issue of benefits for citizens and consumers.

Options

7.112 In view of the above, we have given further consideration to the potential for adopting a different approach to the release of cleared spectrum in Northern Ireland. We have specifically considered three options, which are discussed below:

- UK-wide lots, in line with our general policy;
- Award distinct Northern Ireland lots separately and later;
- Build flexibility into the auction design to allow bidders to express their own preference for UK-wide lots or Great Britain and Northern Ireland lots separately.

UK-wide lots

7.113 As outlined above, we have a general presumption in favour of this approach unless there is a strong indication that the market would prefer licences with a smaller coverage. The available evidence on market demand for cleared spectrum supports this option. In analysis of potential uses of the cleared spectrum undertaken for the first DDR Consultation in December 2006, stakeholders expressed a clear preference in accessing spectrum with UK-wide coverage and very limited interest in spectrum with a smaller coverage. In our latest stakeholder research stakeholders again expressed their preference for being able to offer UK-wide services.

7.114 In contrast, we have had no firm expressions of interest from stakeholders wishing to provide services that are Northern Ireland-only in geographic scope or all-Ireland. In part this may be because the Republic of Ireland has not yet developed DSO plans in sufficient detail, including the identification of any digital dividend, for stakeholders to assess the potential for such new all-Ireland services.

7.115 The UK-wide option would also result in spectrum in Northern Ireland being released, and available for new services there, at the earliest possible opportunity. Although cleared spectrum in Northern Ireland will not be available for use until 2012, an early award of spectrum will provide service providers with time to make the necessary preparations to roll-out services at the earliest opportunity; an operator planning a UK-wide service will have the opportunity to commence roll-out in areas of the UK where digital switchover takes place early, and then to extend transmission networks into Northern Ireland when the spectrum becomes available there in 2012. This therefore maximises the probability of Northern Ireland citizens and consumers gaining access to services from DSO (such as additional broadcasting and mobile communications services) and thereby benefiting from access to the proven economies of scale associated with the UK market.

7.116 The choice of UK-wide lots also facilitates a less complex auction design and minimises aggregation risks for bidders potentially interested in providing all-UK services (i.e. the risk that they would win Great Britain spectrum but not Northern Ireland spectrum and then need to secure Northern Ireland spectrum via the secondary market). Aggregation risks would however remain for bidders interested in providing all-Ireland services.

Northern Ireland lots separately and later

7.117 Under this option, cleared spectrum in Northern Ireland would be held back until there is greater clarity on the Republic of Ireland digital switchover plans. Once this was achieved, we would consider ways to coordinate release of cleared spectrum in Northern Ireland with the release of any digital dividend in the Republic of Ireland, potentially following the conclusion of international negotiations between the UK and the Republic of Ireland to coordinate the spectrum within the GE-06 framework. A precedent exists for this type of packaging in the release of spectrum at 1785-1805 MHz in Northern Ireland. The release of this spectrum was coordinated with the release of the same spectrum by the Republic of Ireland while using two separate auction processes. A key factor in the decision to coordinate the release of 1785-1805 MHz with Republic of Ireland was that the spectrum was available in the Republic of Ireland and Northern Ireland but was not available at that time in Great Britain. This is not the case for cleared spectrum.

7.118 This option would make it easier for bidders interested in providing all-Ireland services to secure coordinated spectrum for this purpose. In the event that the same bidder was to win corresponding spectrum in the Republic of Ireland and Northern Ireland, and subsequently roll out an all-Ireland service with it, this would maximise spectrum efficiency and minimise wasted spectrum at the land border. However, the Northern Ireland award would need to be carefully designed in order to minimise aggregation risks, or in other words, to minimise the chance of a bidder wishing to deploy services on both sides of the border winning Republic of Ireland spectrum but not Northern Ireland spectrum or *vice versa*. The UK and Republic of Ireland operate different regulatory regimes. The challenge of devising an award in Northern Ireland auction which successfully accommodated these differences should not be underestimated.

7.119 It is also important to note that, at this stage, the Republic of Ireland has not finalised its digital switchover plans. In its "Proposed strategy for managing the radio spectrum: 2008-2010," published on 6 March 2008,[49] Ireland's Commission for Communications Regulation (ComReg) commented that:

> As DTT is rolled out in Ireland from 2008, spectrum requirements for digital broadcasting will become clearer. ComReg will then be in a position to develop a strategy to identify the available Digital Dividend spectrum. In the meantime, ComReg will monitor developments in Digital Dividend strategies among EU and CEPT Member States. ComReg is seeking views on the approach that should be taken to releasing this dividend and possible applications that should be taken into account in order to best utilise the spectrum.

7.120 Moreover, the choice of this option would make it difficult for bidders interested in providing UK-wide services to secure the spectrum they would need to roll-out UK-wide services. To do so, they may need to be successful in two separate awards held at different times. Also, even if a bidder was able to secure suitable spectrum in Great Britain and then Northern Ireland on this sequential basis, it would be difficult to plan Northern Ireland services from the time of the award in Great Britain. Accordingly, selection of this option would be likely to result in significant delays to the roll-out of services in Northern Ireland and the loss of benefits to Northern Ireland citizens and consumers after DSO as a result of this.

Auction flexibility

7.121 Under this option, Great Britain and Northern Ireland spectrum would be auctioned at the same time (in 2009) in a single process, but with flexibility built into the auction for bidders to express a preference for UK-wide lots or for Great Britain-only and Northern Ireland-only lots. Where the value of the combination of any separate bids for Great Britain and Northern Ireland lots was greater than for UK lots, the spectrum would be awarded in this way.

7.122 This approach would allow the market to make the trade-off in the primary award between the potential advantages of access to UK-wide spectrum and the advantages of acquiring Northern Ireland spectrum in anticipation of aggregating it with the Republic of Ireland spectrum at a later date. By the time of the UK award in 2009, it is possible that further consideration will have been given to the potential scope and nature of a digital dividend in the Republic of Ireland, informed by EU consideration of these issues.

7.123 This option may therefore allow bidders who are only interested in offering all-Ireland services to win spectrum in Northern Ireland only, rather than having to bid for UK-wide spectrum, or having to obtain the Northern Ireland spectrum they need post-award from UK licensees via the secondary market.

7.124 In practice, however, such bidders are likely to need to anticipate the market demand for Great Britain-only spectrum in order to bid efficiently, given the inevitable increase in threshold risks that more geographically disaggregated lots would introduce to the UK auction. Such risks would not be so significant under the UK-wide lots option. Moreover, as set out in the following section on Auction Design, the proposed design of the UK DDR cleared award is already complex. Adding a further level of

[49] www.comreg.ie/_fileupload/publications/ComReg0820.pdf.

complexity would increase the risks of inefficient auction outcomes and may even be impractical to design.

Preferred option

7.125 At this stage, we continue to favour UK-wide lots. The evidence we have received to date indicates that the majority of stakeholders are interested in accessing cleared spectrum on a UK-wide basis and wish to provide services that address a UK-wide market. We also think that demand for cleared spectrum in Northern Ireland is likely to outstrip supply, so that there would be material costs in holding it back from the UK-wide award.

7.126 We also note that, while the GE-06 Agreement constrains the extent to which certain "high power, high tower" services could be rolled out in Northern Ireland without further international coordination, it would potentially still be possible to roll-out new services across much of Northern Ireland, even on channels where we currently have no agreed GE-06 assignments, by using an adapted transmission network and other mitigation techniques.

7.127 Nevertheless we will continue to communicate closely with our counterparts in the Republic of Ireland in advance of the award of the UK cleared spectrum award in 2009 in order to get a better outline of the likely international coordination outcome, and to seek to optimise the coordinated limits through bilateral agreement.

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

Crown Dependencies

Guernsey and Jersey

7.128 We noted in the DDR statement that both Guernsey and Jersey had indicated their preference to be included in the DDR cleared award—that is, for the geographic coverage of the licences to be awarded to include the Channel Islands. However, as noted in section 5, much of the cleared spectrum in the Channel Islands has very significant constraints placed upon it in the GE-06 Plan. This situation is further complicated because a definitive assessment of potential interference from France cannot be made until France establishes its own DSO plan. We do not expect this until later in the year.

7.129 At present, our best assessment is as follows:

- channels 32 and 33 are coordinated in the GE-06 Plan for an EIRP of 36 dBW (4 kW) in both Guernsey and Jersey. These channels are slightly out of the aerial group (nominally channels 35-53) for the Channel Islands' GE-06 allotment (channels 41, 44, 47 and 51), but the small reduction in aerial gain should not significantly affect coverage, which would be sufficient to provide a DTT service across the Channel Islands. It would also be possible to establish a DTT multiplex on each island using channels 32 and 33 in combination with channel 48, available on an interleaved basis. Other uses are also possible, although there would not be sufficient capacity to establish 3G mobile services;

- channel 65 is only cleared for very low-power use in south Jersey as it was intended to be used as a low-power gapfiller for DTT to cover minor coverage deficiencies in the south of the island. There is very limited scope for anything

other than providing another gapfiller for DTT (e.g. for new services in channels 32, 33 and/or 48), should this be required, or possibly for a WiMAX service; and

- the remaining cleared spectrum is not coordinated for use under the GE-06 Plan. Any services using this spectrum would need to ensure that the exported interference field strength at the French coast did not exceed 23 dBµV/m. Current French military use of channels 66-68 further limits the exportable interference to even lower levels unlikely to be usable from the Channel Islands. In addition, the Channel Islands could expect high incoming interference levels from France's coordinated GE-06 allocations. These will limit the services that can be deployed to low-power ones such as WiMAX, but the base-station transmit power would have to be carefully controlled to limit interference toward France. However, if France decides to implement two-way mobile services in the upper cleared sub-band and we obtain a coordination agreement with France, it may become possible to deploy such services in that spectrum in the Channel Islands. Other services, such as mobile television, will not be able to achieve a wide coverage of the Channel Islands as they cannot achieve suitably high field strength using the existing transmitter sites. However, a dense, single-frequency, lower-power, closed network could be designed, subject to meeting the coordination limits.

7.130 Table 7.3 summarises the overall possibilities.

Table 7.3 Possible uses of the available cleared spectrum in Guernsey and Jersey

Use	Issues
DTT	Most suited use. A single transmitter on Jersey could provide almost full coverage of the Channel Islands, but viewers in Guernsey and Alderney would need a second antenna for reception. A more costly single-frequency network would overcome this problem by using the main transmitter on each island, but further interference analysis would be required. One or more of channels 32, 33 and 48 could be used for additional HD services.
WiMAX	WiMAX deployment should be possible on both islands. The frequency separation from DTT should be sufficient to avoid any interference problems.
3G mobile	There is not enough spectrum in the GE-06 Plan to make operation viable without coordination being agreed with France.
Mobile television	The available ERP would only be sufficient to provide coverage with a cell radius of about 1.5 km depending on terrain. This could be used to cover St. Peter Port in Guernsey and St. Helier in Jersey.

7.131 In the light of this information, the authorities in Guernsey and Jersey are interested in stakeholders' views on whether the available cleared spectrum in the Channel Islands should be included in the licences subject to this award or instead be awarded separately (possibly coordinated between the two islands).

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

Isle of Man

7.132 We noted in the DDR statement that the Isle of Man had indicated its preference for a separate award of the available cleared spectrum there. This amounts to channels 40, 66, 67 and 68. However, like France and as noted earlier, the Republic of Ireland has not finalised its DSO plans, preventing a definitive assessment of potential incoming interference.

7.133 Different use of the same spectrum in the UK and Isle of Man raises the prospect of interference. This will need to be addressed in due course.

Conclusions

7.134 In this section we have explained our preference for offering a large number of UK-wide auction lots in the DDR cleared award in a simultaneous process. This will maximise the flexibility of the auction to accommodate a wide variety of different packaging outcomes, depending on the demand expressed at the auction.

7.135 This flexible approach is particularly important given the diversity and uncertainty of the potential efficient uses of the spectrum. It will allow users with requirements for large amounts of contiguous or non-contiguous frequency to co-exist with users with more specific and limited requirements.

7.136 Nevertheless, complete flexibility to accommodate all possible permutations of demand would imply a very complex and unwieldy process. In striking the balance, we have developed proposals for five distinct sets of TLCs reflective of the types of network likely to be deployed in the spectrum, as set out in section 5.

7.137 The licences with TLCs suitable for DVB-T and MMS type networks would be awarded as lots of 8 MHz, with those for DVB-T based on the existing broadcasting channel plan. Licences with TLCs suitable for mobile communications applications (using both FDD and TDD technologies) would be awarded with flexible-frequency rasters, which we have proposed are based on the 5 MHz channel width that is currently reflected in industry standards and CEPT band planning.

7.138 Because the adjacent channels to the awarded spectrum will continue to be occupied by other uses following the award, these other uses must be protected from undue interference via licence conditions. Some of these conditions are likely to have material consequences for the value of spectrum awarded in frequencies adjacent to the existing users, and accordingly we have proposed to define a series of frequency-specific lots for the award which seek to reflect these material value impacts and hence mitigate substitution risks in the auction.

7.139 Further differentiations have also been proposed, to reflect the potentially significant value differences between channels 36 and 38 and other channels included in the award, and between the upper and lower sub-bands.

7.140 In all, these proposals would imply around 35 categories of lots in the auction – with some lot categories including a number of frequency-generic lots available, and others only one frequency-specific lot. Bidders would however typically only need to specify demand for a small number of these lot categories, and the auction outcome would imply that only that sub-set combination of licence types which maximised total bid value would be awarded. For example, the auction design would permit outcomes where only DVB-T lot categories were awarded, suitable for expanded DTT services, or that licences suitable for mobile communications dominated the award outcome.

7.141 In the next section we discuss the options for an auction design which will enable efficient allocation of the available spectrum on the basis of these packaging proposals.

Section 8

Auction format and rules

Introduction and summary

8.1 In this section we develop proposals for the design of an auction which will allocate the spectrum packages discussed and defined in section 7 in a way which meets our objectives for the DDR cleared award.

8.2 Spectrum auction design is a specialist and evolving area. We have therefore had regard both to existing precedents and to the specific characteristics of the DDR cleared award, including the desirable packaging for the auction, and the nature of the likely bidders. We have developed our proposals with advice from our auction advisers, DotEcon.

8.3 In order to define auction rules at the detailed level, it is first necessary to determine the appropriate broad auction format to be used. The selection of an appropriate format in turn requires decisions to be made over a number of related issues, bearing in mind the specific features of the award concerned. These features, and the implications for basic auction format, are examined in turn in this section.

8.4 However, once a basic auction format has been chosen, it is still necessary to develop more detailed specifications for the auction, which customise it to the particular circumstances of the award. In the case of the DDR cleared award, many of the key issues are associated with the number of specific lot types we identified in section 7 as potentially being necessary to support efficient spectrum allocation in this award. The specification of lot types can affect both the efficiency of the auction and its complexity.

8.5 The other key practical consideration to be borne in mind is the extent to which there may be competition concerns, which can lead to both an increased risk of strategic behaviour in the auction and to a risk that the auction outcome will materially lessen the level of competition in the markets for which spectrum is used. There are a number of ways in which these concerns can in principle be addressed through auction design, and we review the relevant options in this section. A more comprehensive discussion of competition issues is included in section 9.

8.6 Incorporation of these various practical considerations leads us to a proposed auction format for the DDR cleared award auction. Following discussion of this format, we then draw out the implications for some of the associated rules which define the details of how the auction would work. Once again, while the format choice has direct implications for some of these associated rules, there are still some important options to be considered in this area, and we set out our views on the key choices to be made in the remainder of the section.

8.7 Before setting out our auction proposals however, we first briefly summarise the work on these areas to date, to provide context for the discussion in the rest of this section.

Work to date

8.8 In our December 2006 consultation, we framed the auction format decision around four key choices for a multiple-lot auction:

- **Simultaneous or sequential sales of lots**, where the decision rested on the extent to which the values of lots were interdependent (i.e. they were substitutes or complements for each other, exposing bidders to substitution and aggregation risk respectively). We indicated that sequential auctions should be ruled out where these interdependencies were significant, as they were likely to be in the DDR;

- **Single or multiple rounds**: here there is a trade-off between the additional market information provided to bidders in multiple rounds, and the simplicity and greater protection against strategic bidding behaviour by strong bidders that single round formats could provide. We suggested that there is considerable common value uncertainty in the DDR and that single bids would not enable bidders to manage aggregation and substitution risks effectively, while there was insufficient evidence of bidder asymmetries and competition concerns to warrant single bids;

- **Generic or specific lots**, where the trade-off was between the simplicity and flexibility offered by generic lots, and the ability to reflect significant value differences (and hence limit substitution risks) via specific lots. We suggested that technical constraints would lead to significant value differences between a number of lots in the DDR award, and hence to at least a degree of lot specificity;

- **Package bids or multiple bids for individual lots**, where the key trade-off was between the advantages of package bidding to remove aggregation risks for bidders needing to assemble particular combinations of lots to meet their needs, and the additional complexity that package bidding could introduce into the auction process. Again, we suggested that the level of complementarity between DDR lots was likely to require a measure of package bidding.

8.9 Overall we concluded that it was likely that a simultaneous, multiple-round ascending (SMRA) auction form would be needed for the DDR cleared award, and compared four generic variants of this form:

- A “standard” SMRA without package bidding but instead with flexibility for bidders to switch their bids between rounds. Depending on switching rules, this format reduces aggregation risks but does not eliminate them;

- A SMRA with package bidding, which allows bidders to eliminate aggregation risks by specifying all permutations of lots they might seek in every round, at the price of imposing a large burden on bidders to evaluate all such bids where there are many permutations available;

- A multi-round clock auction followed by sealed bids, using generic lots. This simplifies bidding in the multi-round stage, as bidders only need to express their linked demand for different categories of generic lot in each round, so that the multi-round stage reveals the market’s allocation of spectrum across these categories. The sealed bids then allow bidders to express preferences for specific package combinations of lots following this outcome. The format addresses both aggregation and complexity issues. However, if lots within a category are of significantly different value, risks for bidders may still remain as they may be unable to express preferences for which lots within a category they want;

- A multi-round clock auction followed by sealed bids, using specific lots, which allows bidders to express their preferences in a more refined manner. However, such an approach is potentially significantly more complex for bidders due to the

large of number of possible packages which they may need to consider during the bidding. This is particularly demanding for bidders for whom there are sets of lots that are close substitutes.

8.10 In the December 2006 consultation we suggested that the significance of aggregation risks in the cleared award would rule out the standard SMRA, while the significant number of lots and hence permutations could rule out a SMRA with package bidding. The choice between using either generic or specific lots in a clock/sealed bid hybrid auction depended on the packaging selected, and on the ability to ensure that auction complexity issues could be successfully addressed.

8.11 As we noted in our December 2007 Statement, most respondents did not feel able to comment substantively on these propositions, particularly without more information in relation to the specific context and allocation process that the packaging and auction proposals were designed to address. In particular, the need to customise appropriate approaches for the cleared and interleaved awards was highlighted, as well as the need to educate stakeholders better about auctions and their objectives, and to avoid an unduly UK-centric approach.

8.12 We have now provided the necessary level of policy context and packaging detail in our December 2007 Statement and preceding sections of this consultation, in the particular environment of the cleared award. This has been supported by an extensive programme of stakeholder briefing on the general principles and detailed applications of auctions in our spectrum awards programme, both in support of our other awards and in the specific environment of the DDR. In the process we have also been able to refine our auction design proposals, taking account of our own awards programme and advice from our auction advisers DotEcon where appropriate.

8.13 In the remainder of this section we set out our auction design proposals for the DDR cleared award based on this foregoing work, beginning with a review of the auction format options in the context of our specific packaging proposals in section 7.

Key auction design decisions

8.14 Firstly, we address the four key decisions set out in paragraph 8.8 above in light of our current proposals for the packaging of the DDR spectrum.

Simultaneous or sequential award of lots

8.15 If, as proposed, we decide to award the spectrum as multiple lots, these can be sold either simultaneously (all at the same time) or sequentially (one after the other).

8.16 As mentioned above, an important consideration is the substitutability and complementarity of the different spectrum lots. In the DDR cleared award, multiple lots would potentially be close substitutes or complements for the different services that could make use of the band[50].

[50] For example, in order to construct a national DTT multiplex using the cleared spectrum, a potential bidder will require lots which can enable broadcast signals that can be received by each of the UK's different aerial groups. Therefore two lots in different aerial groupings may be strong complements, since a national network would ideally require access to both. However, two lots within the same aerial grouping may be substitutes, so that a bidder looking to roll out a national DTT multiplex may largely be indifferent to obtaining one or the other. Similar considerations apply to the other potential services which may make use of this spectrum.

8.17 The existence of close substitutability and complementarity can cause problems for bidders in sequential auctions. Participants must bid for one lot without knowing what the price of other substitute lots will be (i.e. substitution risk) or whether they will be successful in winning all the complementary lots they ideally need (i.e. aggregation risk). By contrast, a simultaneous approach can allow bidders to manage aggregation and substitution risk across lots.

8.18 We therefore propose that the auction for the cleared DDR award features simultaneous bidding.

Single round (sealed bids), multiple rounds (ascending bids)

8.19 Both single round, sealed bid and multiple rounds, ascending bid auction formats are commonly used for assigning radio spectrum. Sealed bids are often favoured for their administrative simplicity and because, where there are significant bidder asymmetries and related concerns about the level of competition in the auction, they can encourage wider participation. However, in the absence of concerns about the level of competition in the auction process, ascending multiple round auctions are considered to produce potentially more efficient outcomes. Bidders can obtain further information on the value of lots by observing the behaviour of competitors for the same spectrum over the course of the auction, thereby refining their assessment of their requirements and potentially mitigating the "winner's curse" – which can occur when a bidder over-values an asset when bidding with incomplete information.

8.20 In situations of common value uncertainty, it is commonly accepted in auction theory and practice that the outcome of the auction will be more efficient if bidders are able to observe the behaviour of their rivals over the course of multiple rounds. In the context of the DDR cleared award, there is significant uncertainty over the evolution of demand for many of the potential uses of this spectrum[51]. At the same time, there may be bidders targeting very similar downstream markets, so they will have a high degree of common value uncertainty. Hence, bidders may benefit greatly from being able to observe how their competitors shift demand in response to prices.

8.21 In addition, bidders may face substitution risks in auctions for multiple lots. For example, without the ability to switch bidding between lots, bidders may pay a higher price for some lots when substitute lots of similar value could have been purchased at a lower price. The SMRA format, which can allow bidders to switch their demand to different lots in response to changes in relative prices, enables bidders to avoid such substitution risks.

8.22 For the auction of the cleared DDR award, there is also a particular case for using multiple rounds so that the market can dynamically aggregate information on the allocation of resources. This is because of the uncertainty, as discussed in section 7, concerning the relative amounts of spectrum that would optimally be assigned to each of the competing technical licence types in the DDR spectrum. To allow the market to determine the relative balance of different licence types awarded for the cleared DDR award, we believe it necessary to hold a multiple-round process to enable the competing demand for technical licence types to achieve an efficient outcome dynamically.

8.23 We believe that a multiple-round process will therefore be appropriate in the case of the auction of the cleared DDR award.

[51] This uncertainty may be especially significant for emerging and evolving services such as mobile multimedia services.

Generic or specific lots

8.24 Multiple lots can be sold either on a specific or generic basis. With specific lots, bidders place bids for lots at specific frequencies. By contrast, with generic lots, bidders simply specify the number of lots that they want at a given price per lot, without the lots being associated with particular frequencies. The translation of lots won at the "generic" stage of the auction into actual frequencies then needs to take place in a follow-up bidding process.

8.25 The use of generic lots is appropriate if, within a given category of lot, the variation in value between lots for bidders is likely to be modest. However, if there are significant differences in the value of lots then these should not be grouped together as generic lots and should be made more specific.

8.26 Lots within this award are likely to contain a number of degrees of heterogeneity. Firstly, there are two sub-bands, the lower (corresponding to channels 31 to 40) and the upper (corresponding to channels 61 to 68). Certain bidders may regard lots within each sub-band as being of approximately equal value but may assign substantially different value between sub-bands. Moreover, lots at the edge of each sub-band are likely to face more severe restrictions in their use due to the need to protect the adjacent existing services of DTT and due to the higher levels of incoming interference from DTT, and the need to protect radio astronomy, and as such may be of a significantly different value to other lots in the sub-band.

8.27 We believe that the multiple lots should be sold in categories which group together lots which are of potentially similar economic value. These lot categories are likely to differ between each of the technical licence types, as each potential bidder may judge the value of lots by criteria unique to the basic type of network and hence the broad type of downstream service that is likely to be deployed[52]. These categories are also likely to contain varying numbers of lots. For example, some may contain a relatively large number, whereas others may only contain a single lot. A proposed lot specification was set out in section 7 and is summarised at paragraph 8.38 below. Where lot categories include a number of lots, we believe it will be important to allow bidders also to express their demand for exact frequencies (from the range that is determined by the outcome of the auction of generic lots) at the end of the auction.

Package bids or multiple bids for individual lots

8.28 In auctions with multiple lots, bidders seeking aggregations of lots may face an 'exposure' risk (or aggregation risk). This risk arises whenever there are multiple lots that are complementary for some bidders: those bidders must bid separately for one lot without certainty over whether, and at what price, they might win the complementary lots. In such a situation, the bidder faces the risk that it might win only a subset of the lots it requires, which would be inefficient. Further, such risk tends to encourage conservative bidding, which may mean that bidders fail to win the appropriate number of lots even though they may have the highest valuation on those lots.

[52] For example a bidder seeking a licence suitable for deploying a mobile multimedia service may have differing values for lots within each of the sub-bands, whereas a bidder seeking to deploy a DTT multiplex may distinguish lots based by which of the UK's aerial groupings it falls into as opposed to the sub-band. Therefore different broad categories of lot may have different underlying valuations depending on the technical licence conditions.

8.29 The standard SMRA, where bidders make separate bids on individual lots, allows bidders some flexibility to shift demand across lots in response to changes in prices, and thus provides some opportunity for bidders to monitor and manage their exposure risks. However, there is always a risk that, as demand for lots diminishes towards the end of an auction, bidders may still become stranded with unwanted lots. There are various ways of adjusting the auction rules to increase flexibility for bidders, such as allowing some bid withdrawals or augmented switching between lots, but none of these can completely eliminate the exposure problem.

8.30 The most effective solution to this exposure problem is to allow bidders to make 'package bids', i.e. linked bids for multiple lots that are accepted or rejected in their entirety. Overall, experimental evidence has shown that where some bidders have complementary demands, auction formats with package bidding tend to produce somewhat more efficient outcomes than auctions such as conventional SMRAs in which demands for individual lots are unlinked and may be accepted or rejected piecemeal.

8.31 The downside of allowing "package" bidding (or "combinatorial" bidding as it is also known) is that the facilitation of aggregation for larger bidders that such auctions offer needs to be balanced against the risk that smaller bidders, who for example might want only individual lots, may be unable adequately to coordinate their demand to displace such larger bidders. This is termed the "threshold problem". The problem is that no one bidder interested in only a small amount of spectrum is likely to be able to outbid another bidder interested in a larger amount of spectrum; it is likely to be necessary for an *ad hoc* coalition of smaller bidders to form through the auction that is collectively able to outbid the larger bidder.

8.32 A further problem is that there may be an incentive for individual small bidders in such an *ad hoc* coalition to seek to "free ride" on the other members of the coalition – i.e. to bid conservatively in the hope that the other members of the *ad hoc* coalition will pick up a larger share of the cost. Since all members of the informal coalition are equally likely to face this incentive (and auction rules will prohibit their communicating with each other), there is a risk that they collectively bid less aggressively than a single, large bidder and, therefore, do not win the spectrum even when it would be efficient for them to do so. The strength of incentives to behave in this manner will depend on the balance between the benefits bidders might enjoy from paying less and the risks of not winning what they want. This will in turn depend in part on the detailed auction rules (especially the pricing rules).

8.33 On balance however, we believe that the benefit of avoiding the exposure risk is significantly the more important factor in the case of the cleared DDR award because of the significant levels of complementarity between different lots. Therefore, we propose to allow combinatorial bidding in the auction to enable bidders to express their preferences for combining lots in the different lot categories in the auction of the cleared DDR award. The different lot categories on which we propose a bidder can place a package bid are detailed below for each technical licence type.

8.34 Other aspects of the auction design can be used to mitigate the "threshold problem" referred to above, to the extent that this problem might exist for this award. As discussed in more detail later in this section, we are proposing to develop a detailed auction design which will aim to provide incentives on all bidders to bid straightforwardly in accordance with their valuation of the lots. In particular, the rule determining the prices to be paid by winning bidders is designed to encourage straightforward bidding.

8.35 The above discussion indicates that the DDR cleared award of the should have the following design features:

- a simultaneous award process;
- multiple round bidding with bidders able to see the prices of spectrum as they are revealed during the auction;
- generic lots where possible, but specific lots where value differences warrant the additional complexity they introduce, using a clock process to elicit the level of demand as the prices for each category of lot are raised, coupled with the opportunity for bidders to specify their exact frequency preferences at the end of the auction; and
- combinatorial bidding (alternatively referred to as package bidding) with open primary bidding rounds when all bidders can see the emerging demand for different individual lot categories as prices for them increase, and a supplementary round where each bidder expresses its demand for the different specific packages that they prefer, subject to any constraints created by their primary bids.

8.36 We consider that a simultaneous multiple-round combinatorial clock auction (CCA) is the most suitable auction design as it can incorporate all the necessary elements required above whilst at the same time providing a simple and intuitive interface for bidders to use during bidding.

8.37 Although the CCA design is relatively new in comparison to the standard SMRA, we have successfully employed it in the recently completed 10 GHz, 28 GHz, 32 GHz and 40 GHz award and the 1452-1492 MHz award. It has also been selected as the format for the upcoming 2500-2690 MHz, 2010-2025 MHz and 2290-2300 MHz ("the 2.6 GHz") award.

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

Practical concerns

Lot definition

8.38 The packaging proposals outlined in section 7 provide a basis from which we can proceed to define the lots in an auction. The proposed lot categories derived in section 7 are reproduced below:

Figure 8.1 Summary of proposed lot categories

The actual frequency location of some of the restricted lot categories would not be fixed in practice; the figure shows possible outcomes.

8.39 As we explained in section 7, there are technical and demand reasons to support around 35 different lot categories for the cleared DDR award, as illustrated in the figure above. All the lot categories concerned would reflect one of five specific technical licence types. Within each technical licence type, there would be some frequency-generic lot categories and some frequency-specific lot categories. For example, for lot categories with DVB-T type licence conditions, lot category 1 above would be a frequency-generic lot category, comprising four 8 MHz DVB-T lots following the existing fixed DTT channel rasterisation. However, lot category 2 would be a specific-frequency lot category, with only one lot, which represents channel 35.

8.40 This variety of different lot categories, as defined in section 7, creates challenges to be addressed in devising the rules for pricing and winner determination in an auction with combinatorial bidding. In a situation such as this, where the lot categories give rise to a situation where there may be both mutually compatible and mutually incompatible bids for the same spectrum frequencies, the auction rules still must enable the winner(s) to be objectively and unambiguously determined at the end of the auction. This can require a complex mathematical algorithm within the auctioneer's auction software in order to achieve this outcome on a timely and robust basis.

8.41 As explained in section 7, the number of permutations of possible outcomes will be particularly large with the relatively high number of lot categories proposed for this auction. The winner determination problem is therefore computationally difficult to

solve. This is to some extent an unavoidable consequence of the large amount of spectrum being sold at once, the various engineering constraints in different parts of the spectrum concerned, and the many different possible uses - with differing and uncertain values – of the spectrum.

8.42 The challenge for the auction software is to identify, in a given bidding round, the internally-consistent, technically feasible band-plans that can be constructed from the bids in that round, and thereby to determine whether the set of bids made in that round implies there is still some excess demand for some of the spectrum. This is required in order to identify where prices still need to be increased to clear the excess demand and when the multiple-round stage of the auction needs to end.

8.43 Our auction advisors DotEcon have proposed a specific methodology for determining the potential band-plans that could be generated from the bids received in each round, given the lot category structure and packaging rules described in section 7. They have advised us that this methodology, though robust, would require significantly more computing resource than we have previously needed given the number of lot categories and hence possible band-plan permutations. Their key recommendations in this area are set out in their report which we are publishing with this Consultation.

8.44 As part of their work, our advisors have estimated the maximum number of feasible band-plans that could be envisaged from the lot categories described in section 7. The structure of lots described in section 7 is quite refined and creates distinct categories wherever factors have been identified that might plausibly cause bidders' valuations to differ materially across lots. On these assumptions about lot structure, the computational demands of solving the winner determination problem are about three orders of magnitude greater than those of the recent 1452-1492 MHz award, which used a similar auction format, but with only two separate technical licence types and 17 separate lot categories. Even in the hypothetical case of taking the simplest conceivable lot structure for this award (differentiating only by type of usage and sub-band) the computational demands of solving the winner determination problem would be about five times greater than those in the 1452-1492 MHz award

8.45 The immediate implication is that it appears feasible to use the lot structure suggested in section 7 and to solve explicitly for the winning bidders, but that this problem is challenging, in computing power terms, to solve quickly. Without specific measures to speed things up, obtaining results could take longer to confirm than would be ideal. Further, the proposed approach would be challenged by any significant increase in the complexity of the lot structure relative to the working assumptions presented in section 7.

8.46 The obvious computing solution to this issue would be to move to the use of a distributed computing approach and to break down the problem into smaller "chunks" that could each be solved in parallel on separate computers. This warrants further investigation.

8.47 However, the computing issue is a direct function of the number of lot categories and associated packaging rules defined in section 7, and so another solution (which could be deployed with or instead of distributed computing) would be to reduce the number of lot categories, and/or constrain further the ways they would be allowed to be packaged together, and thereby reduce the number of feasible band-plan permutations which need to be included in the winner determination algorithm. There would be significant benefit in simplifying the lot structure where possible, by

reducing the number of categories. We explore the possibilities for this in the following paragraphs.

Reducing complexity

8.48 Although we believe that the lot categories set out in section 7 reflect material value differences (and hence are justified on efficiency grounds) and would result in an auction which is feasible to run, there is the potential significantly to reduce the computational burden by simplifying the packaging somewhat – perhaps by eliminating a handful of lot categories. In so doing, distinct lot categories would need to be retained where sufficiently significant value differences potentially existed. Otherwise, any simplification might result in inefficient outcomes from the auction. We explore possible simplifications in the lot structure for each technical licence type below.

DVB-T

8.49 A number of potential simplifications could be made within this technical licence type. For example a generic lot category which encompasses channels 35 and 36 could be created if we believe that the early availability of channel 36 was not an important driver of value for a bidder seeking to build a DTT multiplex. For example, it might be that a bidder will not be able to extract much benefit from earlier availability of channel 36 if its DVB-T service required multiple lots; service roll out might be constrained by the last available lot.

8.50 A more radical simplification could group together all the channels 31 to 36. This would mean that a bidder would initially bid for a certain number of lots in the category, but would not know which specific lots might be acquired. Having won a certain number of lots within the category, the specific frequencies awarded would be determined by the further bidding process proposed for frequency allocation purposes. However this approach may risk not reflecting the realities of aerial grouping and their impact on the values of different channels for DTT-type uses.

8.51 A further alternative might be to group channels 35, 36 and 37, as these have the same aerial group. However, use of channel 37 would be encumbered by protection for radio astronomy. If there were sufficiently significant valuation differences between the three channels, there might be a risk of bidders not knowing which they might secure in a further bidding process to determine the specific frequencies awarded.

MMS

8.52 In section 7 we proposed that MMS lots did not generally follow the fixed-frequency rasters established for television broadcasting. This allows the frequency-location of MMS lots in a winning band-plan to be adjusted to enable more efficient spectrum packaging. However, this flexibility could be replaced by a requirement for MMS lots to follow the fixed-frequency broadcasting rasters, which would reduce the feasible band-plans that could emerge and hence simplify the auction at the potential expense of less efficient packaging.

8.53 Another possible simplification is to combine lots directly above and directly below channel 38 into a single category. The rationale would be that both types of lots would be subject to usage restrictions to protect radio astronomy in channel 38, and given the similarity of the restrictions would be likely to have similar value and be substitutable for most bidders. Against this however, because only the top 6 MHz of

channel 38 is used by radio astronomy, the restrictions on channel 39 would be greater than those in channel 37, as set out in section 5, such that equating the two channels for lot categorisation purposes might ignore material value differences.

8.54 Furthermore, we proposed in section 7 to distinguish between lots in the lower and upper sub-bands, in part because the most economic use of some technologies such as DVB-H may be in the lower sub-band. However it may be that the value differences between lots in these different locations (with the exception of channel 36) are not very large.

TDD

8.55 There are only three lot categories proposed for the TDD technical licence type, in part due to the size of frequency separation required from existing DTT transmissions. Therefore there is less potential for further simplification of lot categories in this technical licence type than for other types.

FDD

8.56 In the case of FDD, the number of lot categories that we identified in section 7 was influenced by the amount of flexibility that bidders could potentially require, in particular to adhere to harmonised spectrum allocation arrangements or not. If bidders have the choice of bidding on lot categories which guarantee correspondence to harmonised international arrangements, or to specific duplex separations, or with a guarantee of contiguous spectrum, *as well as* lot categories which offer more flexible allocations, a greater number of lot categories would be needed. This increases the amount of computer processing required for winner determination. Equally, if some options can be definitively ruled out in advance – so that technical parameters including duplex spacing, duplex gap size and potentially guaranteed adherence to fixed frequency rasters are defined in advance of the auction – the number of feasible band-plan outcomes could be radically reduced and the computing problem thereby simplified.

8.57 One specific simplification that could be made to the lot structure described in section 7 for the lower sub-band is to collapse the three categories of FDD downlink lots above channel 38 into a single category. This is a significant simplification. Although there may be differences between the characteristics of the three lots, it seems likely that a typical bidder would probably want more that one of these lots, greatly reducing the impact of differences in value between them. Furthermore, if there is FDD downlink use of spectrum in the lower sub-band above channel 38, no dissimilar uses can be accommodated in this range. Therefore, there may be little efficiency cost in making FDD downlink spectrum in this range only available as a bundle of three 5 MHz usage rights if it is unlikely that these usage rights would, if allocated, go to different winners.

8.58 A similar simplication could be made in respect of the three FDD downlink lots defined for the interleaved spectrum in channels 61 and 62. While the nature of the geographic availability of spectrum differs between these two channels (due to the pattern of DTT transmissions), such differences may not be sufficiently material to justify distinguishing three separate lot categories.

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

Competition

8.59 We noted in section 3 that in discharging our duties to further the interests of citizens in relation to communications matters and the interests of consumers in relevant markets, where appropriate by promoting competition, we have, in respect of our spectrum functions, a duty (under the Wireless Telegraphy Act 2006) to have particular regard to the desirability of promoting:

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

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

c) the development of innovative services; and

d) competition in the provision of electronic communications services.

8.60 Accordingly we have assessed the proposals in this document against their ability to promote the efficient management and use of the spectrum concerned, and the economic and other benefits that would flow, as well as their ability to stimulate the development of innovative services and promote competition in relevant markets. Our approach to promoting competition and efficiency in the award and use of the cleared spectrum is also discussed in section 9 below. At this point we summarise the main implications of our assessment for the detailed design of the auction.

8.61 The first key conclusion of our assessment was that it is important in auction design for this award to create, as far as possible, a level playing field between the wide variety of potential bidders for the same spectrum. These will potentially range from large incumbent communications industry participants to smaller new entrants. Accordingly, in finalising the detailed auction design we will pay particular regard to minimising the opportunities for collusion and strategic bidding, and for reducing the potentially distorting impact of information advantages held by large, well-resourced, bidders and risks that could be faced by smaller bidders in a combinatorial clock format auction.

8.62 Our proposal for small lot sizes, grouped into alternative lot categories, explicitly customised to particular network requirements, should enable the widest possible range of uses to be reflected in different bidders' participation in the auction. Similarly, our proposal to group similar, closely substitutable lots into generic categories should simplify the auction for bidders and permit bidders to pursue substitute targets easily. Our packaging proposals therefore are designed to help address the desirability of promoting competition and innovation.

8.63 The simple multi-round format of the combinatorial clock auction enables bidders of all types to reduce common value uncertainty as bidders will be able to see aggregate information about demand at various price levels and update their views about the likely market value of spectrum. With an appropriate information policy, the benefits of the pooling of information about value that occurs naturally through markets can be achieved by an auction without giving individual bidders opportunity to behave strategically (for example, though tacit collusion or predatory strategies).

8.64 Nevertheless, the cleared award will necessarily involve bids being made with potentially a high level of uncertainty about valuation remaining, particularly for new entrants with more innovative business models or technological aspirations supporting their bids. We are therefore particularly concerned to foster effective and

complementary secondary markets for this type of spectrum and, as set out in section 9, believe that the most efficient way to do so will be via the award of technology and use-neutral licences, without pre-specified roll-out or usage obligations, but with requirements (as described in section 6) to provide information on usage that will assist in the development of such secondary markets.

8.65 Within the broader framework created by our proposed auction packaging and format, there are however also potential opportunities to promote competition, entry and innovation through the ways in which some of the detailed auction rules are framed.

8.66 As set out in section 9, we think that there may be a case for the imposition of a safeguard spectrum cap, set at a level which would secure a diversity of spectrum allocation without unduly constraining efficient spectrum use. This could help to promote opportunities for a variety of different bidders to acquire and use the cleared spectrum. We propose that it may be appropriate to set this cap at the level of 50 MHz enforced via the auction rules (so that the limit on eligibility at the outset of the auction would be limited to this amount of spectrum).

8.67 We have also borne in mind the need to facilitate competition and wide participation in the auction in developing our proposals for other auction rules, as set out in the remainder of this section. In particular, we have considered the needs of bidders that may be in receipt of public funding (to reflect the broader social value of particular intended uses of the spectrum), in developing auction rule proposals in relation to information disclosure, deposits and payments of licence fees.

Proposed auction format

8.68 As noted above at paragraph 8.36, we consider that the combinatorial clock auction format is the most suitable design for the award of the available spectrum. We now explain in more detail the specifics of this auction format and how it can be tailored to the needs of the award considered in this consultation document. Note that these proposals are to some extent contingent on our proposals on packaging and basic auction format. While we do not expect the fundamental structure of the auction design to require material change, there may be a need to revisit some of the more detailed specific design features, in light of responses received to this consultation and as a result of further ongoing work. We will be consulting on the detailed auction rules to be set out in the relevant Regulations for the award in due course. Nevertheless, the information provided below should allow respondents to provide informed comments on our key proposals.

Available spectrum and usage rights

8.69 There is a total of 144 MHz of spectrum available in this award, comprising 128 MHz of cleared and 16 MHz of interleaved, with 80 MHz available in the lower sub-band and 64 MHz in the upper sub-band. Section 7 set out our proposals for the packaging of the available spectrum, with the proposed lot categories being summarised at paragraph 8.38 above. This shows that we have proposed around 35 different lot categories to be made available in the auction across five different technical licence types (excluding channel 38), and that not all of the available spectrum is available for use in each of the five technical licence types.

8.70 For the purposes of this award, the 144 MHz of spectrum will be divided into 144 blocks of 1 MHz each and it is these blocks that will be the basic unit used for determining the frequencies that will be assigned to the different licences awarded in

the auction. Bidders will be able to bid on lots of 5 MHz or 8 MHz i.e. 5 or 8 contiguous blocks of 1 MHz spectrum, the size depending on the technical licence type being bid on[53].

8.71 Spectrum in the auction could be allocated to any compatible combination of lots across the lot categories, depending on the bids received in the auction. In the event that spectrum within a sub-band is allocated to a range of lot categories with multiple technical licence types, then dissimilar technical licence types must be separated by a minimum number of 1 MHz guard blocks. The minimum separation requirements have already been explained in section 5, but are summarised again in Table 8.1 below. In addition, in the event that spectrum in a sub-band is assigned to more than one TDD user, then each TDD user must be separated by at least 5 MHz (i.e. 5 x 1 MHz guard blocks). There are no separation requirements for lots within other technical licence types in the case that there is more than one winning bidder with the same technical licence type.

Table 8.1 Summary of guard band requirements

	DVB-T	MMS	TDD	FDD up	FDD down
DVB-T	na	5	16	16	5
MMS		na	19	19	5
TDD			na	5	5
FDD up				na	10
FDD down					na

Overview of the award process

8.72 The combinatorial clock auction proposed for this award is the same basic format as used in the 10-40 GHz award and the 1452-1492 MHz award and which is proposed for the upcoming 2.6 GHz award. The auction proceeds in five stages and the following illustrates how each of these stages may progress in the award of the available spectrum:

- **Application Stage.** Prospective bidders submit their applications to participate in the award, including submitting their initial deposits. Details of bidder groups are then notified to other applicants.

- **Qualification Stage.** 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. Prospective bidders also have an opportunity to withdraw. We announce the number and identity of the qualified applicants. If there is only one bidder, the bidder will be entitled to select the frequency blocks it wishes to purchase 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.** This stage determines the identity of the winning bidders and the number and category of licences that they will receive. It comprises two phases of bidding:

[53] As noted in section 7, Channel 38 is a special case and is always awarded on the same restricted basis regardless of the other group and categories awarded.

- **Primary bid rounds.** The first phase of the Principal Stage consists of primary bid rounds, which will follow a clock auction format. Bidders make a single bid each round for a package of lots in response to a set of prices which we notify to them. Each package bid must contain a feasible combination of lots from one or more of the available lot categories. All bids for lots are on a generic basis; within each lot category, bidders could be awarded any lot within a specified frequency range that meets the specified requirements (although some lot categories contain just one lot defined by frequency).

  We increase prices for some or all of the lot categories in each primary bid round, depending on the level of demand in the previous round. During the primary bid rounds, bidders may maintain or reduce their "activity level" (the total number of lots they choose to bid for) in response to these changing prices. The primary bid rounds continue until there is a round where there is no excess demand for any blocks; i.e. where all bids submitted in that round can be accommodated in the available spectrum, taking into account any requirements for separating adjacent users and lot categories.

- **Supplementary bids round.** The second phase of the Principal Stage 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 alternative packages of lots across categories, subject to constraints created by their primary round bids.

  We then identify the highest value combination of bids that can be accommodated, drawing on all valid package bids from the primary and supplementary bids rounds and taking at most one package bid from each bidder for this combination. This determines the number of lots of each category that each bidder will win. A 'base price' for each winning bid will also be identified, based on all bids made by all bidders. At this point, we will also determine the frequency allocation of 1 MHz blocks to each lot category, including the location of any guard blocks and unsold blocks, if applicable[54].

- **Assignment Stage.** This stage determines how the available frequencies for lots within the generic lot categories that have been allocated in the Principal Stage are distributed amongst the winning bidders for the lots in each generic lot category. Bidders can make "assignment round bids" for particular ranges of frequencies. These bids must be compatible with the number of lots that they won in the Principal Stage in each lot category and with other specific conditions where applicable.

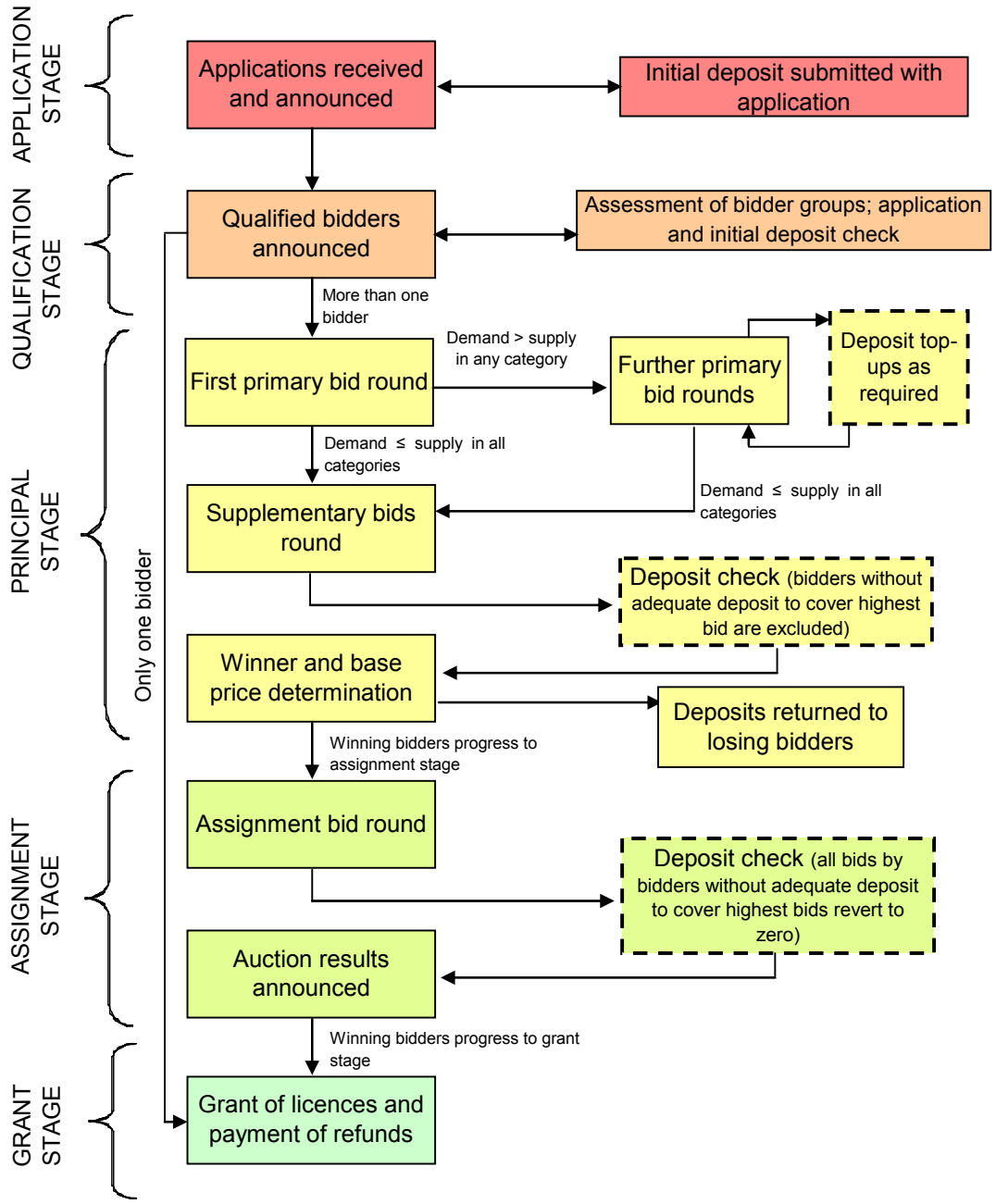
  We then identify the highest value combination of bids that can be accommodated, subject to certain conditions. A final price for each bidder is also identified, which combines the base price and any additional prices paid for specified frequencies arising from the Assignment Stage.

[54] In the interests of simplifying the assignment stage, Ofcom is currently minded to determine the usage of each 1 MHz block prior to the assignment stage and so determine a unique band plan at the end of the principal stage. Bidders would then be able to make assignment stage bids to express preferences over the specific frequencies of their lots subject to this band plan. An alternative approach might be to allow a number of band plans that are compatible with the number of lots awarded in each category at the end of principal stage to be carried through to the assignment stage (in situations where there are multiple alternatives). This would create a greater range of options for bidders in the assignment stage (which may however be problematic if the number of options is large).

- **Grant Stage.** 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.

8.73 The flow chart in Figure 8.2 below provides an overview of the whole process

Figure 8.2 Flow chart illustrating the auction process



8.74 In the following paragraphs we describe the proposed auction rules and procedures for each stage in further detail. These draw on the detailed auction rules and procedures adopted in previous Ofcom combinatorial clock auction awards, as well as reflecting some specific features of the DDR cleared award process. As such, these proposals may be subject to amendment in light of the specific characteristics of this award once decisions over packaging and basic auction format have been

finalised. Nevertheless they provide a basis for illustrating how the proposed combinatorial clock auction could work in practice in this spectrum award.

Application Stage

8.75 In previous awards, we have published on our website the day and time by which applications to participate in the auction must be submitted, with applications only being acceptable from bodies corporate. In this stage, applicants will also probably be required to provide details of associates and members of its bidder group who are not associates, along with their deposits.

8.76 In the 10-40 GHz award we set the initial deposit at £25,000 and in the 1452 – 1492 MHz award it was set at £50,000. We have set the initial deposit at £100,000 for the 2.6 GHz award. The level of the initial deposit should be sufficient to incentivise compliance with the auction rules during the Application and Qualification stages. We envisage that an initial deposit in the range of £50,000 to £100,000 would be appropriate for this award.

8.77 When prices in the auction subsequently rise significantly above the reserve price, the initial deposits may become inadequate to provide the appropriate compliance incentives, and thereby protect other bidders in the auction. For this reason, the auction rules are likely to include requirements for the deposits to be topped up before the start of the auction and then as bidding increases during the auction, which we indicate in discussing subsequent Stages below.

8.78 Disclosure of confidential information[55] by a member of a bidder group to parties outside the bidder group may result in an applicant not being qualified to bid or in a bidder being excluded from the award process and losing its deposit.

Qualification Stage

8.79 Rules to prohibit collusion and bidder association will be important given that this will be a multiple round auction. Penalties will need to be adequate to deter such behaviour. The nature of the rules and penalties is likely to be similar to those put in place for other recent spectrum awards. As such, it is likely that we will notify each applicant of the names and associates of all other applicants and set a date by which applicants must notify us as to whether any members of their bidder group are also associates of another applicant. We are also likely to consider whether any members of one bidder group are also members of another bidder group.

8.80 We will next determine which applicants are qualified to bid in the auction. An applicant may not qualify if a member of its bidder group is also a member of another bidder group as indicated above. We will also take into account a number of other matters, e.g. whether:

- the grant of a licence to an applicant would be likely to prejudice national security;
- the applicant is a fit and proper person to hold a Licence;
- the applicant has submitted false or misleading information;

[55] Confidential information is generally defined in auction regulations as information about an applicant or bidder that is not in the public domain and which, if disclosed to another applicant or bidder, would be likely to affect their decisions in relation to the award process.

- the applicant or any member of its bidder group has colluded or attempted to collude or is colluding or attempting to collude with any other person to distort the outcome of the award process, or has acted or is acting to distort the outcome of the award process;

- the applicant or any member of its bidder group, or any person to whom confidential information has been disclosed, has disclosed, or is disclosing or attempting to disclose or has incited or is inciting another person to disclose confidential information to anyone other than to a member of its bidder group, Ofcom, a provider of finance (where the disclosure was for the purpose of raising finance for the application), or a person considering whether to join the bidder group of the applicant;

- the applicant or any member of its bidder group has received or is obtaining or attempting to obtain confidential information relating to another applicant;

- the applicant or any member of its bidder group is receiving or attempting to receive services in relation to the award process from anyone who has provided or is providing services to Ofcom in relation to the award process; or

- any member, or director or employee of a member of the applicant's bidder group who is also a director or employee of a member of another applicant's bidder group is taking part in the preparation of both bidder groups for participation in the award process or receiving confidential information relating to both bidder groups.

8.81 We will notify each applicant as to whether it has qualified to bid in the auction and of the last day on which applicants who have qualified may withdraw their application without forfeiting their initial deposit. After the last day for withdrawal, we will probably publish the names of all applicants qualified to participate in the auction who have not withdrawn, and announce the procedure that we will follow for award of the licences (depending on the number of bidders). An overview of the different procedures that may apply is provided below

If there are no bidders

8.82 If there are no bidders, there would be no auction and we would consider an alternative award process.

If there is only one bidder

8.83 If there is only one bidder, there would be no auction and the bidder would be entitled to select the lots it wishes to purchase from a defined set of options up to its eligibility. After we receive the completed licence selection form (and associated relevant licence fee, based on the reserve prices for the licences concerned) we would grant the bidder a licence or licences for the frequency range or ranges selected.

If there is more than one bidder

8.84 Where there are two or more bidders, the award would progress to the Principal Stage and bidders would top up their deposits and thereby define their initial eligibility to bid in the auction.

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

Principal Stage

8.85 The Principal Stage would consist of two phases as described above. In the first phase there would be one or more primary bid rounds, with the second phase being a supplementary bids round.

The primary bid rounds

8.86 The primary bid rounds would follow a clock auction format. Under this auction format the auction would proceed in discrete rounds, with all bidders making bids within the same fixed time window[56].

8.87 In any given primary bid round, each bidder would submit a single bid for a package of lots across one or more lot categories. In submitting a bid, bidders specify the number of lots of a particular category that they wish to bid for at the prevailing round prices for each category of lot. The number of lots bid for in each category cannot exceed the total available for that category, and the total number of lots bid for by an individual bidder across all categories must be feasible (in the sense that it could be a winning bid if it were, hypothetically, the only bid). Each bid would be for a package of lots, which means that each bid would only be considered in its entirety and would not be subdivided.

Scheduling primary bid rounds

8.88 Primary bid rounds would be scheduled at our discretion, with bidders being notified of the start time of a round prior to its commencement. Along with the notification of the next round's start time, each bidder would also be provided with additional information, which is likely to include:

- the duration of the round;
- the prices that would apply to lots in each category in the round;
- their eligibility to bid in the round (potentially expressed as a number of eligibility points) - see below; and
- their number of remaining extension rights - see below.

8.89 We propose to retain discretion over the scheduling of primary bid rounds, which includes discretion over the number of rounds per day, as this is an important tool available to us, together with retaining a level of discretion over round price increases (see below) in managing the duration of the auction and hence in conducting an orderly and efficient process.

Primary bid round prices and price increases

8.90 In the first primary bid round, the price per lot would be set equal to the reserve price for that category of lot. This might simply be set on the basis of the number of 1 MHz blocks contained in each type of lot. For example, if there was a reserve price of

[56] This is subject to the provisions for extensions, described further below at paragraph 8.132.

£10,000 per 1 MHz block for the blocks required to make up a lot in a given lot category, the opening price would be £80,000 for any 8 MHz lot comprising such blocks.

8.91 In each subsequent round, we would set a new price for each lot category, which would be the same or greater than the price for that category in the previous round. Prices would be increased for lot categories for which there is excess demand. Excess demand could be the result of demand for more lots in an individual category than the maximum available, or because the total demand for lots in different categories is not mutually compatible within the total spectrum available.

8.92 The amount by which prices would increase from round to round for each block will be at our discretion[57], with this discretion likely to be subject to a pre-defined cap on the maximum increase. For example in previous auctions we have set this cap at 100%. In practice, we would expect to use this discretion in order to set larger price increases for blocks where there is a greater level of excess demand and thereby manage the progress of the auction.

8.93 Because the frequency of spectrum required for lots in different lot categories will typically overlap and comprise mixtures of frequency-specific and frequency-generic lots, assessing the relative level of excess demand for each lot category will not be straightforward in this auction. We may therefore choose to inform our discretion by defining in advance some objective procedures for indicating excess demand.

8.94 A potential issue is that the application of pre-defined and automated formulae to derive estimates of excess demand, such as the process indicated above, could result in excess demand being identified for one lot category, but not for other categories that are in practice substitutes at least for some bidders (e.g. those providing similar usage rights at different frequencies). If prices were increased only for the lot category where a formula indicated the existence of excess demand, these bidders could switch their demand to a substitute, lower-priced, category in the next round. In this way many bidding rounds might be needed to reveal the relative market values of lot categories that were partial substitutes, risking an unnecessarily long auction.

8.95 This problem can be addressed by deeming some lot categories to be partial substitutes for each other, and increasing the price of all such categories together in defined situations of excess demand. This would shorten the auction, though it will require some prejudgement of the extent and significance of substitutability between lot categories. On this basis we could retain the discretion to increase prices for categories with no excess demand if there is at least one lot category with the same type of technical licence in excess demand, subject to the increase being capped by the increase applied to the category in excess demand. For example if one MMS lot category had excess demand in a given round and a 20% price increase was applied as a result, we could retain discretion also to increase the prices of some or all of the other MMS lot categories by up to 20% in the next round.

Activity rules

8.96 The purpose of a multi-round auction is to reduce common value uncertainty by incentivising each bidder to express their demand for spectrum at different prices in subsequent rounds. If bidders can hide demand, by bidding for less spectrum in early rounds than they actually want at the prevailing prices, this purpose would be

[57] Probably subject to a rule that lot category prices could not fall in the primary bid rounds.

frustrated. Multi-round auctions therefore have activity rules which are designed to prevent such behaviour and encourage bidders to express their actual demand (at prevailing prices) in each round of the auction.

8.97 There are two basic potential approaches for defining the activity rules in the combinatorial clock auction. The first relies on a system of eligibility points which establishes, in advance of the auction, an assumed relative value of each lot, and then applies these relative values throughout the auction. The second incorporates the information on the relative values of lots that is generated by the market during the auction, and is accordingly known as revealed preference.

8.98 An eligibility point based approach was used in the recently-completed 10-40GHz and 1452-1492 MHz awards. Under this approach, when each bidder places their initial deposit with us to participate in the auction, the size of this deposit determines their initial eligibility to bid for some or all of the spectrum on offer (subject to any spectrum caps in place) at the start of the auction. Thereafter this eligibility can be sustained throughout the subsequent bidding rounds of the auction, or decrease when bids for smaller-value packages of lots are made. Eligibility throughout the auction can only stay the same or decline, and cannot increase, so bidders are prohibited from hiding aggregate demand in the early stages.

8.99 These eligibility point activity rules aim to force bidders to reveal information about their valuations for the spectrum and not to withhold information on their intentions and values until later stages of the auction. This information revelation enables other bidders to make more informed decisions as to whether to continue bidding in the auction (including whether to switch demand between available lots) and increases the likely efficiency of outcomes.

8.100 Ideally however, the eligibility points should reflect the final true relative values of lots. This reduces the incentives for strategic behaviour by some bidders in the auction, such as 'parking'[58] eligibility on lots in early stages of the auction. However, these final true relative values can only be estimated in setting the eligibility points at the start of the auction, and will always be inaccurate to a greater or lesser extent. The risks to efficiency of inaccurate estimates increases the greater the differences actually are in values between different lot categories and the greater the levels of common value uncertainty that exist at the start of the auction (which will extend to the regulator setting the eligibility points in advance).

8.101 In the case of the DDR cleared award, there will be value differences between different lot categories. Different technical licence types are likely to have different values even if they use the same number of underlying 1 MHz blocks. This might be because the licence type permits different uses (e.g. DVB-T and MMS both use 8 MHz lots but may not have the same value) or because some licence types are subject to restrictions and greater interference due to their proximity to existing services and because those in the interleaved spectrum being of lower value than other, unrestricted, lots.

8.102 While the presence of value differences implies that there should in principle be differences in the relative weights of eligibility of lots, such differences will be difficult to estimate accurately and consistently in advance. However, this problem should not be overstated for the following reasons.

[58] i.e. preserving eligibility on lots that are relatively cheap, as measured by their initial eligibility points, either to hide true intentions or to maintain eligibility to punish other bidders if tacit collusion breaks down.

8.103 A significant proportion of the underlying 1 MHz blocks are fungible amongst a variety of uses. This feature will effectively act to tie the respective prices per MHz of the different frequency-generic lot categories more closely together. For example if spectrum was fully fungible between two lot categories and their per MHz prices differed significantly, demand in the auction would switch and act to reduce the price relativities between the two. It may be appropriate therefore to set a common weight for the 1 MHz blocks required for the different frequency-generic lot categories.

8.104 However in the DDR cleared award, some lot categories will be both highly frequency-specific, and very different in value terms from the frequency-generic categories. Accordingly the 1 MHz blocks that these lot categories require would not be fungible with the frequency-generic block requirements. For example, lots within the geographic interleaved channels 61 and 62 or channel 38 may be expected to have a significantly lower value than the other available channels for all bidders. Conversely, lots within channel 36 may be expected to have a significantly higher value than the other available channels due to its earlier availability, at least for some bidders where the value is not complementary with other spectrum. It may be possible to derive relative weightings in advance for the thirty-two 1 MHz blocks in these four channels and set eligibility point weightings on this basis.

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

8.105 An alternative to setting fixed weights for different categories of lots required by an eligibility points based eligibility rule is to use a form of revealed preference activity rule. This is a weighting scheme for eligibility points that reflects bidders' behaviour in response to the previous rounds' relative prices. This approach has a number of theoretical attractions which are discussed below. First however, we discuss in more detail how an *ex ante* eligibility point activity rule may work in practice based on experience in recent awards. To illustrate how this may work we take a simple example of where each 1 MHz block has the same eligibility value assigned to it and ignore the issue of weighting eligibility points discussed above.

Eligibility points

8.106 Assume that each 1 MHz block in the auction has an initial eligibility of 1 point at the start of the auction. Any package bid in an auction round has an associated "activity" level that is determined by the sum of the eligibility points associated with that package. Thus, a bid for an 8 MHz lot has an associated activity of 8 points and a bid for a 5 MHz lot has an associated activity of 5 points. On the same basis, a package bid has an associated "activity" level that is determined by the sum of the eligibility points associated with the lots in the package. A package bid may be for multiple lots across multiple lot categories. Thus, for example, a package bid containing 3 MMS lots and two DVB-T lots would imply an activity of (3 x 8 + 2 x 8) = 40 points.

8.107 Prior to the start of the auction the initial eligibility for each bidder would be confirmed and would be based on the size of deposit prior to the first round. Each bidder would receive 1 eligibility point per whole £X of deposit. For example, if one eligibility point was provided for each £10,000 of deposit, a bidder with a deposit of £160,000 would have an initial eligibility of 16 points.

8.108 As the minimum size of any lot in the auction is proposed to be 5 MHz then, if all 1 MHz blocks had the same eligibility points, the minimum total initial eligibility would

be 5 points, with this being sufficient to bid for either one TDD lot, one FDD downlink lot or one FDD uplink lot. The maximum eligibility points that were theoretically available per bidder would correspond to the total amount of available spectrum. As noted above, this is 144 MHz of spectrum so the maximum initial eligibility would be 144 points. However, as discussed in section 9, we propose that the auction rules specify a lower maximum limit on eligibility points to implement a safeguard cap.

8.109 From the second primary bid round onwards, each bidder's eligibility is determined by their activity in the previous round. Specifically, each bidder's eligibility limit in any round from round 2 onwards is equal to the number of eligibility points associated with their package bid in the previous round. For example, assume that Bidder A had an eligibility of 40 points in round 8. He then bids in round 9 for a package consisting of four MMS lots. The number of eligibility points associated with his bid is 32 points (4 x 8), so his eligibility in round 9 would fall to 32 points.

8.110 As the primary bid rounds progress, bidders may use their eligibility to bid on lots in any permitted lot category. Therefore, it is possible that a bidder's activity for any particular lot category may increase, provided that the bidder's activity in other permitted categories is sufficiently reduced.[59]

Revealed preference

8.111 As noted above, an alternative to an *ex ante* eligibility point activity rule is to have a revealed preference activity rule. This is a rule which provides bidders with an incentive, as the auction proceeds, to reveal which combination of lots they most prefer at the given relative prevailing prices, in preference to all of the other available combinations of lots. In the context of an auction activity rule, what this would do is limit the ability of a bidder to change its relative valuations of different combinations of lots as the auction progresses.

8.112 In a strict form, a revealed preference activity rule would prevent a bidder from bidding on a combination of lots at prices which were inconsistent with its bidding behaviour in previous rounds of the auction. A bidder would, in each and every round, have to bid in a manner consistent with its bidding behaviour in earlier rounds. If a bidder revealed in one round that it preferred a combination of lots A to combination of lots B when the combination of lots A was £10,000 more expensive than the combination of lots B, that bidder could not then bid on the combination of lots B in a later round unless it had become at least £10,000 less expensive than the combination of lots A in the meantime.

8.113 In the context of an auction where it might be expected that a bidder's relative valuation of different combinations of lots may change (for example there exists significant common value uncertainty), such a strict form of a revealed preference activity rule would be undesirable. This is because such a strict form of the activity rule would prevent a bidder from expressing changes to its relative valuations of different combinations of lots in light of all the different information that is revealed as the auction progresses. Therefore, in such circumstances it is desirable to consider a form of revealed preference activity rule which imposes a less severe constraint on a bidder's behaviour through the auction.

8.114 A relaxed revealed preference activity rule would allow a bidder to revise its relative valuation of a combination of lots as the auction progresses. However, in doing this,

[59] This is subject to the discussion of introducing additional restrictions on bidder behaviour at paragraphs 8.117 to 8.125 below.

the activity rule cannot risk allowing a bidder to hide its true relative valuation of combinations of lots in a way which could potentially undermine the underlying efficiency of the auction process. In particular, bidders should not be able to hide what they truly want until late in the principal stage, as this undermines the progressive revelation of information about valuations that the open primary bid rounds provide. Therefore, such a revealed preference activity rule would need to strike an appropriate balance between giving a bidder sufficient flexibility to reflect its change in relative valuations between combinations of lots, in light of information revealed from the auction, and not providing so much flexibility that a bidder could manipulate bids in a way such that the efficiency of the auction is undermined.

8.115 In broad terms there are two main (potentially interacting) dimensions in which the activity rule can be adjusted in order to strike this balance. One is the amount by which a bidder can revise its relative valuation of combinations of lots as the auction progresses, and the other is for how many rounds of the auction its previous bidding behaviour is taken into account.

8.116 We intend, following this consultation, to explore further the potential to develop a revealed preference activity rule for the specific characteristics of this award. In particular, we will consider how the strict form of the activity rule could be relaxed such that it could allow bidders to revise their valuations as the auction progresses. We will also explore the challenges for bidders in making bids consistent with a revealed preference activity rule given the constraints generated by previous bids and whether such challenges would undermine the benefits of using a revealed preference rule. We are also mindful of the risks of strategic behaviour, with the associated risks that these could have for the efficiency of the auction outcome.

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

Other potential restrictions on bidder behaviour

8.117 The simplified illustration of the eligibility point activity rule above assumed that bidders would have the flexibility to bid on multiple technical licence types and categories of lots within a single package and to switch demand across different lot categories as the primary bid rounds progress. However, allowing bidders to have complete switching flexibility in the primary bid rounds may provide opportunities for bidders to engage in strategic bidding, thus threatening the efficiency of the auction outcome. It is therefore necessary to consider whether a more restricted approach should be adopted, which reduces the flexibility of bidders to express demand across different technical licence types within a single primary bid round, as the primary bid rounds progress and in the supplementary bids round.

8.118 The benefit of a more restricted approach is that it could constrain the opportunities for strategic bidding (for example, a bidder hiding demand for communications type licences by bidding for broadcasting type licences in early rounds or *vice versa*). However, on the other hand restricting bids in this way would limit bidders' opportunities to adjust their genuine demand in response to emerging relative price signals for the different lot categories as the auction progresses. In broad terms, there are four options available for imposing such aggregation and substitution constraints in the auction:

- no restriction on the ability to bid on multiple technical licence types within a single package or on the ability to switch demand between different technical licence types as the primary bid rounds progress;

- restricting the technical licence types on which a bidder can bid throughout the auction to some 'pre-qualified' technical licence group (determined in the Application and Qualification Stages);

- imposing a restriction on the technical licence types on which a bidder can bid in the primary bid rounds, but not in the supplementary bids round; and

- imposing a restriction on the technical licence types on which a bidder can bid in the supplementary bids round but not in the primary bid rounds.

8.119 In addition to these four broad options, it is also possible that some hybrid variation of these may be appropriate, where some substitution between technical licence types is allowed, but other forms of substitution between technical licence types is restricted.

8.120 In the DDR cleared award, we consider that the opportunities for strategic bidding are potentially greater than in the previous combinatorial clock auctions which we have run. The main reasons for this include:

- there is likely to be a greater number of lot categories;

- there is probably greater relative scarcity of suitable lots, such that lot category prices may become quite different from each other as the bidding progresses;

- there is likely to be a greater mix of bidders seeking quite different quantities of spectrum at the same time (with associated threshold risks); and

- there is a greater risk that some potential bidders will hold a position of market power in relevant downstream markets.

8.121 These factors, when taken together, might suggest that there is reason for imposing some restriction on bidders' ability to bid on multiple technical licence types within a single package and to switch demand across different technical licence types as the auction progresses.

8.122 However, there are other factors that suggest that bidders should be able to retain some flexibility to aggregate different types of licence within their packages and to switch demand as the auction reveals information to bidders. In particular some of the different technical licence types are at least partial substitutes for each other (and can in principle become more so through agreed technical licence condition changes after the auction), while in other cases bidders may wish to obtain spectrum with more than one technical licence type. This means that if bidders were to be required to only bid on a single technical licence type throughout the whole duration of the auction they may not be able to manage efficiently the substitution and aggregation risks that such restrictions would create.

8.123 An implication of introducing restrictions on bidders' ability to bid on multiple technical licence types and switch demand between these as the auction progresses is that it is conceivable that some bidders that are interested in acquiring spectrum with different technical licence types, even where these may not be substitutes for each other, would be prevented from doing so. For example, restricting bidding on DVB-T licence types and FDD and TDD licence types in a single bid would prevent a bidder acquiring spectrum suitable for a DTT multiplex and mobile broadband at the same time.

8.124 This may lead bidders to want to be a member of more than one bidder group in order that they are not precluded from obtaining access to spectrum with the different technical licence types concerned. Under the bidder association rules applied in previous Ofcom awards, which we outlined above under the Qualification Stage, bidders would be prohibited from making such arrangements. However, if such restrictions on bidder behaviour within the auction were to be introduced it might in principle be appropriate, in order not to preclude efficient spectrum allocation outcomes, to amend some of these bidder association rules. For example if the auction rules prohibited a bidder from switching between (say) lot categories with DVB-T and MMS licence types, a broadcaster might express a wish to participate in more than one bidder group.

8.125 That said, there are a number of potentially very significant downsides to such an approach. These include the opportunities that such relaxation might create for collusive behaviour, which would also undermine the efficiency of the overall spectrum award process, and accordingly such options would themselves require the investigation of more complex rules on information exchange. Additionally, such an approach would probably create significant implementation problems in terms of amending the legal framework which has been developed for the other combinatorial clock auctions which we have run and in developing software which could accommodate multiple bidder identities from the same location, given the need for robust security measures. Moreover, it might be the case that the risks to efficiency derived from the introduction of restrictions on bidder behaviour can be sufficiently addressed through more sophisticated switching rules in the auction.

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

Other auction rules in the primary bid rounds

8.126 In the primary bid rounds, there is a need for other auction rules to help ensure that the outcome of the auction leads to an efficient spectrum allocation. These are now discussed in turn below, which for illustrative purposes is in the context of a simple eligibility point activity rule with complete flexibility for bidders to substitute demand across all lot categories. In practice the detailed rules concerned would need to be rendered internally consistent with the approaches adopted for eligibility and switching rules.

Increasing deposits during the primary bid rounds

8.127 During the primary bid rounds, we would, at any point and on any number of occasions, announce a deadline by which time bidders must have raised their deposits so that they remain in line with their highest bid up to that point in the auction. This helps to ensure that bidders do not submit bids in the primary bid rounds which they are subsequently unable to pay for. Accordingly this rule helps to manage the credit risks imposed by individual bidders on the efficiency of the auction process.

8.128 If a bidder does not meet a deadline for increasing its deposit, its eligibility would be reduced to zero in the next round after the deadline, and it will in consequence not be able to participate in any further primary bid rounds. Based on practice in our previous combinatorial clock auctions, such a bidder would, however, still be able to participate in the supplementary bids round as explained below, subject to the

constraints on bids implied by its eligibility dropping to zero in the relevant primary bid round and subject to meeting the rules on making bid deposits to support its supplementary bids.

8.129 For example, consider a bidder that had eligibility of 16 points in round 8 but then did not raise its deposit as required by Ofcom by the relevant deadline before the start of round 9. Its eligibility would drop to zero in round 9. In the supplementary bids round, the bidder would still be able to make bids for packages with eligibility up to 16 points, but its maximum bids for such packages would be capped on the basis of the prices for each category of lots that applied in round 9. The bidder's round 8 bids would still also be valid for the purpose of determining aggregate excess demand and hence whether there should be another primary bid round and, if so, whether the round price should be raised for a particular lot category.

Submitting primary round bids

8.130 We propose that, as with our other combinatorial clock auction awards, primary round bids would be submitted using an electronic auction system. To make a bid, bidders would select the number of lots in each lot category that they wish to include in their package. The choices available to bidders would be subject to the following constraints:

- their total eligibility;
- within each lot category, the selected lots in each lot category would not exceed the maximum available for that lot category; and
- where the package involves lots in more than one lot category, the aggregate number of lots demanded within each category must be mutually consistent (in the sense that it would be possible to award this number of lots if this were the only bid).

8.131 Once a bidder had selected the package for a primary round bid, it would be automatically checked by the electronic auction system software for compliance with the above constraints. Once a bid had been checked as compliant by the electronic system the bidder could then formally submit it via the electronic system or, alternatively, revise its proposed bid (which would then also be checked by the electronic auction system before it could be submitted).

Extensions

8.132 An extension right allows a bidder additional time in which to submit a primary round bid beyond the deadline which we would specify for that round. In the event that a bidder with eligibility and one or more remaining extension rights fails to submit a bid during a primary bid round by the relevant deadline, the round would automatically be extended for that particular bidder, and one of its remaining extension rights deducted.

8.133 These extension rights are provided to bidders as an emergency tool in case, owing to unforeseen circumstances, they are unable to submit a bid during a primary bid round by the prescribed deadline[60]. The overall intention of extension rights is to

[60] In the event of significant problems that prevented a number of bidders accessing the electronic auction system, we would envisage using our exceptional powers to reschedule or re-run a primary bid round, rather than relying on extension rights.

provide a backup against technical failures, rather than to provide bidders with extra time to consider their decisions. For example, if a bidder had problems with its Internet connection and cannot access the electronic auction system, it could use an extension right.

Submission of primary round bids in exceptional circumstances

8.134 Where a bidder is unable to submit a primary round bid using the electronic auction system, there is likely to be a process by which the bidder could seek our permission to submit a bid using either fax or email. Where we granted such permission, the bidder would need to submit its bid using the agreed transmission mechanism, i.e. either fax or email (in these circumstances bids submitted electronically would not be accepted unless we had expressly agreed) and within the deadline specified by us.

8.135 If a bid submitted by fax or email exceeded the bidder's eligibility, or was illegible or unclear, the bid would be invalid and the bidder's eligibility in the following round would fall to zero and, as a consequence, it would not be able to submit any further primary round bids. However, the bidder would be able to participate in the supplementary bids round, subject to the constraints on bids implied by its eligibility dropping to zero in the relevant primary bid round, and subject to meeting the rules on making bid deposits to support its supplementary bids.

Information available during the primary bid rounds

8.136 Before the start of the first primary bid round, each bidder would be notified of their own initial eligibility. This information would not be provided to other bidders. At the end of each primary bid round, we would reveal to each bidder:

- the aggregate demand for lots by category;
- information about a bidder's own bids, their eligibility in the next round, the amount of that bidder's highest bid in the auction to date, and how many extension rights the bidder had remaining.

8.137 There are a variety of possible approaches that could be taken to providing additional information about bids made in the previous round. Short of providing full transparency of all bids made, it is possible to provide bidders with information about anonymised individual demand in previous rounds. However there are advantages and disadvantages with this additional transparency beyond aggregate demand. On the one hand the information can help reduce common value uncertainty. For example, with additional transparency bidders may get more information about the valuations of other bidders, with likely similar ultimate uses of the spectrum, for particular lot categories. This may reduce common value uncertainty to a greater extent that only seeing information about aggregate demand. However, particularly in the later rounds when there are limited bidders for a range of lot categories, such transparency can reveal information about bidding strategies which can serve to increase the risks of inefficient strategic bidding such as tacit collusion or predatory bidding strategies targeted against particular opponents.

8.138 In practice the incentives for strategic bidding in the primary bid rounds are also influenced by the eligibility and switching restrictions, as discussed above, and accordingly we propose to determine the approach to information available in the primary bid rounds in conjunction with final decisions on these associated rules.

End of the primary bid rounds

8.139 The primary bid rounds end when there is a round in which all the bids submitted in that round can be simultaneously accommodated in the available spectrum, taking into account all requirements for separations between users. At this point the auction would progress to the supplementary bids round.

8.140 In addition, following the close of a given primary bid round, we may announce that we are terminating the primary bid rounds phase early and proceeding to the supplementary bids round (i.e. while demand is still above supply in one or more lot categories). We would expect only to terminate the primary bid rounds early if we believed that this was in the general interest of running an efficient award process. This could for example occur where there was limited remaining excess demand, and we considered that continuing with further primary bid rounds was unlikely to reveal significant further information to bidders.

The supplementary bids round

8.141 In the supplementary bids round, bidders may submit a series of parallel bids for different packages of lots, subject to respecting the eligibility restrictions resulting from their bids in the primary bid rounds. This round would provide an opportunity for bidders to bid for packages of lots that they were eligible to bid on in the primary bid rounds but that they did not bid for, and also to express the maximum amount they are willing to pay for packages that they did bid on in a primary bid round, again subject to their eligibility constraints.

8.142 All the package bids received from all the bidders in both the primary bid rounds and the supplementary bids round are then considered together in order to determine the winners of the Principal Stage of the auction.

8.143 Unlike the primary bid rounds, where bidders simply indicate their willingness to pay for packages at the prevailing round prices that we set for the lot categories concerned, bidders must choose the monetary amounts of any supplementary bids they make. These bid amounts are subject to a minimum and in some cases a maximum as described below.

Restrictions on supplementary bids

8.144 All supplementary bids would be bids for distinct packages of lots from one or more of the available lot categories.

8.145 For each of those packages where the bidder had already submitted a primary bid, they would be able to submit one more bid for the same package in the supplementary bids round, the monetary value of which would need to be greater than the highest bid made by the bidder for that package in the primary bids round.

8.146 Bidders would also be able to submit supplementary bids for other packages of lots for which they had initial eligibility at the start of the auction but where they did not make primary round bids. As bidders can only submit one primary bid in each round, there may be other substitute packages that they would be willing to accept but on which they had not made primary bids. Furthermore, a bidder's preferred package early in the primary bids round could have been based on relative lot category prices which subsequently changed after they lost the eligibility to switch into a new preference. In the supplementary bids round the bidders would have the flexibility to

reveal their preferences for other lot categories. Once again, the bidder would only be able to submit one supplementary bid for each such alternative package.

8.147 We will probably also set a limit on the total number of supplementary bids that a bidder can make in this round. In the 1452-1492 MHz award, where there was the mathematical possibility to construct approximately 130,000 alternative packages from the lot categories available, we placed a limit of 2,000 on the number of supplementary bids per bidder, although in practice no bidder submitted more than 21 bids in the supplementary bids round.

8.148 In the cleared award there will be a large number of possible packages that can be constructed from the available lots, and therefore a practical cap on the number of supplementary bids will again be required. In determining the level of this cap, one of the key considerations will be how this affects complexity for bidders and for us. We are currently minded to again limit the number of supplementary bids to 2,000 per bidder as we did in the 1452-1492 MHz award. This is likely to be sufficient, as we envisage that bidders will not likely be interested in acquiring spectrum across all of the categories of lot and a limit of this size would strike a balance with managing complexity for bidders and for us.

8.149 Some supplementary bids would probably be subject to an upper bound on the amount bid. There would be no such upper bound for packages that were bid for in the final primary bids round and for other packages that have associated eligibility points which are less than or equal to the bidder's activity in the final primary bid round.

8.150 For supplementary bids for packages which had eligibility points above the bidder's activity in the final primary bid round, the bid amount is likely to be capped to be the price that would have applied to that package in the round where the bidder was last eligible to bid for the package concerned. This type of rule should ensure that the eligibility rules effectively constrain bidding behaviour in the supplementary bids round, and thereby encourage efficient bidding behaviour in the primary bids round. In the event that a revealed preference activity rule was used instead of an *ex ante* eligibility points activity rule, the constraint on supplementary bids would need to take a different form. This would be intended to provide incentives for bidders to bid on their most preferred packages throughout the primary bid rounds

Preparing supplementary bids

8.151 In previous Ofcom combinatorial clock auction awards, we have made available to bidders an electronic supplementary bids management tool with which they have been able to maintain and revise a list of provisional supplementary bids throughout the primary and supplementary bids rounds. This has also provided information about all primary round bids submitted by the bidder and the associated constraints on supplementary bids that arise from these primary round bids. We will consider whether such an electronic tool should be made available as part of this award.

Submitting supplementary bids

8.152 Supplementary bids would be submitted electronically within the specified timing for the supplementary bids round. Bidders will also probably be provided with the ability to submit their supplementary bids outside of this specified time period in exceptional circumstances. The process for submission of supplementary bids in exceptional circumstances is likely to be similar to that described above for the submission of primary round bids in exceptional circumstances.

Deposit rules for supplementary bids round

8.153 It is likely to be a requirement for bidders to have a prescribed amount on deposit with us before participating in the supplementary bids round, based on bidding in the primary bids round. Following the supplementary bids, bidders would probably be required to top up their deposits again, to reflect their supplementary bids, by a prescribed deadline.

Winner determination

8.154 Following the close of the supplementary bids round and completion of the deposit checks, we would proceed to determine the winning bids for the Principal Stage. Collectively, it is likely that we will define such bids as being those which constitute the single combination of valid primary and supplementary bids of greatest total value amongst all the valid bids submitted, subject to the conditions that:

- no more lots are awarded than are available;
- at most one package bid is accepted from each bidder;
- if lots are awarded from more than one lot category, then a sufficient number of blocks are allocated as guard blocks between any adjacent pair of dissimilar lot categories (or different TDD users);
- subject to these guard block requirements, it is possible to meet all the winning bids from the available spectrum;
- assignments of TDD lots to a single bidder are contiguous in a given sub-band;
- at least in the Upper sub-band, in the case that the number of FDD downlink lots is greater than or equal to the number of FDD uplink lots:
    - winning bidders are able to pair all their FDD uplink lots with a corresponding downlink lot with a common duplex separation for that bidder across all pairs; and
    - assignments of FDD uplink and paired downlink lots to a single bidder are contiguous.

8.155 Because the FDD downlink lots in the lower sub-band could in principle be paired with corresponding uplink lots at higher or lower frequencies, it may not be possible both to guarantee both a common duplex separation across all pairs of FDD lots, and guarantee that all assignments of FDD lots are contiguous in the lower sub-band. Final allocation rules will need to be determined in the context of finalising the lot category specifications for packaging purposes.

8.156 A computer programme will be used to determine the specific combination of all the bids that meets such pre-set criteria. It is possible that there could be more than one set of bids having the equal greatest total value based on such a definition. In the case of such a tie, the tie would be resolved by selecting the combination of bids with the highest number of associated eligibility points. If a tie still remained, then a process of random selection would be used in the electronic software to select the winning set of bids.

Base price determination

8.157 The next stage of the process would be to determine the base price associated with each winning package bid. A base price is an overall price for the entire package of lots which constitutes the winning package bid concerned. A separate base price would need to be determined for each winning package bid within the overall winning combination.

8.158 We expect base prices to be calculated using a second price rule similar to that used in other combinatorial clock auctions that we have run. Such a rule in the combinatorial clock auction has good incentive properties with regard to bidders placing bids which reflect their true valuations and as such aids an efficient allocation of the available spectrum. For the set of winning bids, there will be an associated unique set of base prices which satisfies the conditions that:

i) the base price of each winning bid is greater than or equal to the total reserve prices of the lots within that winning bid; and

ii) there is no alternative combination of bidders prepared to pay more than any winner or group of winners; and

iii) of the different sets of base prices satisfying conditions i) and ii), the total of the base prices is minimised.

8.159 The base prices which satisfy these conditions will never exceed the corresponding prices actually bid by winning bidders. If there is more than one such set of base prices (which equal the same total) the set which is closest to winners' opportunity costs would be selected[61].

Announcement of results to bidders and changes to deposits

8.160 Once we have determined the winning bids and their associated base prices, the identity of the winning bidders and the number of lots won in each category by each winning bidder would be notified to all bidders.

8.161 In addition, each winning bidder would be told the base price that applies to their own winning bid. This information would not be released to other bidders at this stage. Winning bidders would also be required to increase their deposit so that it covered 100% of their base price, within a stipulated period. A winning bidder that failed to meet this deposit requirement would forfeit its deposit and be excluded from the award process, with the lots identified in its winning bid not sold in the award.

8.162 Losing bidders, applicants who did not qualify and applicants who withdrew before the last day for withdrawal would all be refunded their deposits at this point, unless these had already been forfeited for any reason.

Determining Assignment Stage options for winning bidders

8.163 After the deadline for the increase of deposits by winning bidders, we would confirm to each winning bidder the lots on which it will be able to submit assignment bids in the Assignment Stage. Every 1 MHz block available in the auction will either be:

[61] Likely to be found by minimising the sum of squares of differences between winners' bid prices and the corresponding base prices.

- allocated to a lot category contained in a winning bid in the Principal Stage;
- designated as a guard block to be allocated to adjacent winning bidders whose identities will be determined by the outcome of the assignment stage; or
- retained by Ofcom.

8.164 There may only be one possible configuration of 1 MHz blocks consistent with the outcome of the winner determination, which will then determine the allocation of guard and unallocated blocks.

8.165 However, there could be multiple configurations of blocks consistent with the outcome of the winner determination. This is particularly likely if there are one or more unallocated blocks after taking account of the requirements of winning bids and guard blocks, and there are a number of possible frequency locations for these unallocated blocks. For example, within 16 MHz (two channels) of available spectrum, three 5 MHz lots could be awarded to a winning bidder, but the residual 1 MHz block could either be identified at the lower or the upper frequency end of the two channels and yet still meet the requirements of the winning bids.

8.166 Where there were such multiple configurations of blocks, we are minded to select the configuration which minimised the amount of unused spectrum (for example selecting a configuration which resulted in the most contiguous unallocated spectrum of at least the amount which triggered its retention for future award by Ofcom, where this could be achieved). If there still remained multiple configurations, then the Assignment Stage could be used to determine the allocation of lots from amongst these possible alternative configurations. Alternatively, we could determine the allocation of lots from amongst these possible alternatives on broader spectrum management grounds.

End of the Principal Stage

8.167 After the deadline for the increase of deposits by winning bidders and the associated confirmation of allocated blocks, we would publish:

- the identity of the winning bidders who had complied with the deposit requirement;
- the identity of any winning bidders that had been excluded from the award process;
- the number of lots of each lot category won by winning bidders;
- the base price for each winning bidder;
- the specific frequencies of 1 MHz blocks to be allocated to each lot category comprised within winning bids;
- the specific frequencies of 1 MHz blocks (if any) to be allocated to winning bidders as guard blocks; and
- the specific frequencies of 1 MHz blocks (if any) to be retained by Ofcom.

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

The Assignment Stage

8.168 The purpose of the Assignment Stage is to determine how the available frequencies in the lots in frequency-generic lot categories comprised within the winning bids are distributed amongst the relevant winning bidders from the Principal Stage, and the final price to be paid by each winning bidder. The Principal Stage would have already determined how much spectrum each bidder will receive and the number and frequency location of 1 MHz blocks to be awarded to particular lot categories, but not necessarily the specific frequency ranges of individual lots within the frequency-generic lot categories that will be assigned to winning bidders.

8.169 There would probably be a separate assignment procedure for each frequency-generic lot category, although bidding and frequency selection would take place simultaneously for all such lot categories. The exact procedure for each lot category (up to a maximum of the eight frequency-generic lot categories affected) would depend on whether there was only one, or more than one, winner of lots in a given frequency-generic lot category.

Scheduling the assignment bid round

8.170 For all lot categories where there was more than one winning bidder, an assignment bid round would be needed unless there was only one way of assigning the lots won in the Principal Stage to the different bidders concerned. We would announce the start time and duration of the assignment bid round after the completion of the Principal Stage.

Determining the bid options for the assignment bid round

8.171 Winning a certain number of lots within a category in the Principal Stage would entail both a right and an obligation to purchase one of the corresponding frequency range options presented to that winning bidder in the assignment bid round. For example, if a bidder won three TDD lots in one of the two frequency-generic TDD lot categories, this would entail a commitment for that bidder to accept any available contiguous package of three lots (15 MHz in total) within the frequencies assigned to the lot category concerned.

8.172 For each lot category where an assignment bid round was required, we would determine a set of frequency range options available to each bidder. For each bidder for paired spectrum in the relevant FDD generic lot categories, we would identify for each bidder an exhaustive list of packages of frequencies that were consistent with the number of lots that they won in the Principal Stage. For some lot categories, bidders would also be guaranteed contiguity and fixed duplex pairs.

Guard blocks

8.173 Where the number of contiguous unallocated 1 MHz blocks (i.e. those that were not needed for winning bids or associated guard blocks) exceeded a pre-set threshold (say, 4 or 7), we suggest that the blocks might be retained by Ofcom as an outcome of the Principal Stage, as described above. Where the number of contiguous unallocated 1 MHz blocks was the threshold figure or less, the relevant spectrum and the minimum guard blocks would both be assigned to the adjacent winning bidders as guard blocks. We envisage applying rules of the following form for this purpose:

- if the guard blocks were located between two winning bidders, then the relevant spectrum would be split equally between them;

- if the guard blocks were located at the bottom of a sub-band, then the relevant spectrum would be awarded to the winning bidder of the frequencies immediately above the guard blocks; or

- if the guard blocks were located at the top of a sub-band, then the relevant spectrum would be awarded to the winning bidder of the frequencies immediately below the guard blocks.

8.174 However, where an assignment bid round is required, the exact location of the individual winning bidders relative to the guard bands concerned would not be known at the end of the Principal Stage. In this case, where the affected winning bidder(s) for spectrum adjacent to guard blocks are to be determined through the assignment bid round, then any spectrum that would be awarded as guard blocks to bidders would be included in their assignment bid options. In this way, bidders could use their assignment round bids to express preferences for frequency adjacency to the guard bands concerned, or not as the case may be.

Submitting assignment round bids

8.175 We expect that the procedure for submitting assignment round bids would be a two-step process, which is similar to that already described for bidding in the Principal Stage:

- in the first step, bidders would prepare bids for each and every feasible frequency range option separately in every lot category where they are eligible to bid, with the electronic auction software being used to ensure such bids were compliant; and

- in the second step, the bids would be formally submitted via the electronic auction software.

8.176 We expect to follow similar rules for permitted bidding amounts as we have adopted in other combinatorial clock auctions where an Assignment Stage is necessary. On this basis the minimum bid for each frequency range option would be zero, with there being no upper limit. Note that all bidders eligible to participate in the assignment round would be guaranteed to win at least the same amount of spectrum in each lot category that they won in the Principal Stage. The bids in this round would only affect the frequency outcomes of the spectrum assignments and potentially guard band allocations, which would be reflected in additional prices paid by the bidders concerned. Bidders would probably again be allowed to submit bids in the assignment bid round outside specified timescales in exceptional circumstances, with the process for submission of assignment bids in exceptional circumstances being similar to that described above for the submission of primary round bids in exceptional circumstances.

Deposit rule for the assignment bid round

8.177 There would again be a requirement for bidders to increase their deposits held by us within a preset time after the assignment stage bids concerned.

Winner determination

8.178 Following the close of the assignment bid round and completion of the deposit checks, we would proceed to determine the frequencies assigned to the winning bids for each lot category. For each lot category, the winning assignment bids would be the combination of valid assignment round bids of greatest total value amongst all valid assignment bids submitted, subject to the conditions that:

- exactly one bid was accepted from each bidder;
- each bidder was assigned the same amount of spectrum in the same lot categories as they won in the Principal Stage, plus guard blocks if applicable;
- each bidder received contiguous frequencies where applicable;
- where applicable, bidders for FDD downlink and FDD uplink licences received spectrum with a consistent duplex separation; and
- the frequency ranges included in the winning assignment bids did not overlap.

8.179 A computer programme will probably be used to determine the combination of bids that meets these criteria. Each bidder would have exactly one winning assignment bid in each category where they won lots in the Principal Stage, because bidders would be presented with a complete set of feasible assignment bid options and would be required to make assignment bids (even if of amount zero) for all such options. It is possible that there could be more than one combination of assignment round bids having equal highest value. In this case, the tie would be resolved using a process of random selection.

Determining additional prices and the licence fee

8.180 In each frequency-generic lot category where there were two or more winning bidders, additional prices would be determined as a result of the assignment round bids, with these additional prices determined using a second price rule in an analogous manner to the Principal Stage.

8.181 The licence fee paid by each winning bidder would then be the sum of their base price for their winning bid package (from the Principal Stage) and any additional prices for the specific frequency ranges assigned to them for this package (from the Assignment Stage).

End of the Assignment Stage

8.182 Once we had determined the winning bids and the additional prices for the Assignment Stage, the results of the auction would be announced to all bidders. In announcing the results of the auction we expect that the following information would be released:

- the identity of the winning bidders;
- the frequency ranges awarded to winning bidders in each lot category; and
- the licence fee to be paid by each winning bidder, including a breakdown of the base price and any additional prices applicable to that bidder.

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

Grant stage

8.184 In the Grant Stage, winning bidders would be granted licences for the frequencies corresponding to the lots that they won in the Assignment Stage, including any guard blocks if applicable.

8.185 Winning bidders would be refunded the amount of their deposit less the price payable for their winning bid, as determined according to the type of rules described above for determining the licence fee.

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

Summary and conclusions

8.186 In this section we have explained our approach to auction design for the DDR cleared award. We consider a combinatorial clock auction is the most suitable auction design as it can incorporate all of the necessary elements required for an efficient auction outcome, whilst at the same time ensuring that the bidding process is reasonably simple and that bidders do not need to make complex strategic judgements when making bids.

8.187 Having determined the most suitable auction design, there are a number of other issues which relate to the detailed auction rules which we have considered. These include:

- the precise structure of the auction process, where we have proposed a five stage process;
- the timing of auction rounds, where we propose to retain some discretion to administer an orderly process but guided by the level of excess demand revealed in the different bidding rounds;
- whether to have an eligibility points activity rule or some form of revealed preference activity rule;
- whether bidders should be constrained in their ability to bid on multiple technical licence types within a single package and to switch demand across different technical licence types as the auction progresses;
- the need for bidders to top up their deposits as the amounts which they bid in the auction increase;
- how the winning bidders will be determined;
- the process by which bidders which have won spectrum in frequency-generic lot categories will be assigned specific frequencies;

- how unallocated spectrum will be added to guard blocks assigned to bidders or retained by Ofcom; and

- how the final prices which winning bidders will pay will be determined.

8.188 The next section considers whether there are any competition issues relevant to the cleared DDR award and if so what if any remedies it would be appropriate to impose to address these concerns.

Section 9

Promoting competition and efficiency

Introduction and summary

9.1 The DDR statement noted that it would be necessary to consider how awarding this spectrum could best promote competition and efficiency in downstream markets. This section sets out our approach to this assessment, and our proposals for how to ensure that competition and efficiency are best promoted through the award and use of the cleared spectrum.

9.2 These proposals reflect our belief that the cleared spectrum provides a particularly important opportunity for the introduction of new services in the UK. This spectrum is valuable because of its position at around 1GHz, combining the benefits of both propagation and bandwidth. As a result of this, it is likely to play a significant role in facilitating the launch of new services, such as higher speed mobile broadband, mobile television, and additional DTT services (for example via the launch of pay TV services or more free-to-view services in standard or high definition), all of which are all likely to be of significant value to UK citizens and consumers.

9.3 Spectrum of this value, in this quantity, does not become available often. Our approach to its award can influence the market structure which emerges as a result of the award. Generally, the more competitive the market structure, the lower the level of market power held by firms in the market, and as a result the more competition and efficiency are promoted. Hence, it is important for us to take particular care to ensure that our approach achieves these goals. As explained below, the promotion of competition and efficiency is important for ensuring that total value to society is fully realised.

9.4 Because of this, promoting competition and efficiency are always important considerations when we are awarding spectrum, and more generally in our approach to spectrum management. The link between competition and efficiency considerations and our duties is set out in section 3. In addition, these and other duties which are relevant to our spectrum management activities are discussed in the Spectrum Framework Review[62].

9.5 In this section we explain:

- why we think competition and efficiency are important for promoting citizen and consumer value from the use of spectrum;
- how our approach to awarding and managing spectrum is designed to promote both competition and efficiency;
- how this approach should be applied in the context of the DDR cleared award, this includes consideration of whether there are specific risks of market failure (which through their impact on market structure would impact on the promotion of competition and/or efficiency) that might require us to take tailored action in relation to any particular potential use of the cleared spectrum.

[62] See http://www.ofcom.org.uk/consult/condocs/sfr/sfr/sfr_statement

9.6 The key conclusions reached in this section are set out in the following paragraphs.

9.7 We believe that the first step in promoting competition and efficiency in the DDR cleared award should be through the design of the spectrum award. This includes for example, using auction design and packaging to help to promote a market structure which furthers competition and efficiency, for example, by enabling entry by new operators (where this is efficient) and by reducing as far as possible asymmetries between bidders which might unduly impact upon their ability to reflect their demand for spectrum.

9.8 We think that there may be a case for us to go beyond this to promote competition and efficiency either by putting in place general safeguards or by intervening to resolve significant risks of market failure which could impact on the market structure which emerges as a result of the award. When considering the case for such intervention we need to pay attention to the costs and benefits of intervention, including the risk of regulatory failure (i.e. the costs imposed if the intervention has unintended consequences) and also take into account that, after the award of spectrum, we retain the ability to resolve significant competition concerns which emerge in downstream markets through our sectoral and competition powers.

9.9 In relation to any general safeguards, we identified that the following provisions might be appropriate given the importance of the spectrum:

- A safeguard spectrum cap set at a level which would secure a diversity of spectrum ownership without unduly constraining efficient spectrum use. This would help to promote opportunities for a variety of different bidders to acquire and use the cleared spectrum. We propose that it may be appropriate to set this cap at the level of 50 MHz but are interested in stakeholder views on whether this would unreasonably constrain their likely demand for cleared spectrum.

- An information provision licence condition which would help reduce information asymmetries between spectrum users and help to facilitate an efficient secondary market. This information provision is discussed below and in section 6 above.

9.10 In order to identify whether there are specific issues in relation to individual potential uses of the cleared spectrum which could result in a significant risk of market failure, we have examined the potential uses of the cleared spectrum, and the potential for their acquisition of spectrum to result in a market structure in which competition and efficiency are not promoted. This analysis has identified a number of potential market failure issues, but of which only one may require us to take further action in the award of the cleared spectrum. This issue relates to the limited availability of cleared spectrum for future mobile broadband services, and the potential for this to limit the number of networks which can efficiently be deployed using such spectrum in the future, relative to the number of players the downstream market could support. In relation to this issue we think that further action may be justified and we are interested in stakeholder views on the significance of this issue and the range of potential solutions. The possible options for intervention are set out below and include remedies such as the use of spectrum caps which are contingent on holdings of sub 1 GHz spectrum for mobile services.

9.11 For the other specific market failure risks identified, our initial view is that these do not require action in the award of the cleared spectrum as the issues are either not sufficiently significant to warrant action (given the costs and risks of intervention on efficient spectrum use), or (if they emerge as significant issues) are better resolved through other forms of intervention.

9.12 In summary, it is important that the DDR cleared award promotes both competition and efficiency in the award and use of the cleared spectrum. We believe that our overall award process will go a long way towards this. We consider in the remainder of this section whether there is a case for us to go further in terms of putting in place general safeguards or other interventions to secure these goals. We conclude that further action may be justified in respect of one specific issue, the limited availability of cleared spectrum for future mobile broadband services. We also conclude that two general interventions may be appropriate, these are a 50 MHz safeguard cap on the allowed purchase of cleared spectrum, and an information provision licence condition that will help facilitate an efficient secondary market. We are particularly interested in views from stakeholders regarding our approach either in general or in relation to the specific issues considered in this section.

Why competition and efficiency are important

9.13 Spectrum is a very valuable resource and is a key input to a wide variety of services. In aggregate spectrum underpins around £37 billion of UK economic activity, equivalent to around 3% of UK annual economic output[63]. It supports a number of services which are of value to society, including mobile communications and broadcasting. Spectrum is likely to remain an important input to these kinds of services in the future and innovation and technological development of services are likely to see the demand for spectrum enhanced.

9.14 Promoting competition through the use of spectrum is important as consumers are likely to benefit through lower prices, and/or higher service quality and innovation where services are provided in a more competitive environment (i.e. where individual players hold less market power). As spectrum is a key input to the provision of many important communications services a more competitive market structure for the provision of these services will be fostered where spectrum is available to service providers in a competitive manner. Auctions for spectrum in the UK have in general facilitated more competitive market structures by, among other things, encouraging new entry.

9.15 Promoting efficiency through the award and use of spectrum is important as citizens and consumers will benefit where spectrum is used efficiently. Given the value of services which are dependent on spectrum, not to use spectrum efficiently would risk depriving citizens and consumers of services that might otherwise have been provided, and could potentially impede UK productivity and economic growth. Inefficient spectrum use could include a service provider not fully using all of the spectrum they have acquired and not trading any leftover spectrum with others who could make better use of it, either because they fail to recognise this opportunity or because of undue difficulties in trading.

9.16 The promotion of competition and efficiency are to some extent linked. Competition in the provision of services will tend to promote efficiency in downstream markets by giving operators incentives to innovate and to provide services more cost effectively, for example by ensuring that the minimum amount of spectrum is used to produce the desired level of output. In some situations there may be a trade off between competition and efficiency, for example, when a market is already relatively competitive it can sometimes be the case that additional entry is inefficient. This can happen when entry results in additional fixed costs which outweigh the competition benefits of entry (as these tend to decline the more firms there are in the market).

[63] See http://www.ofcom.org.uk/research/radiocomms/reports/economic_spectrum_use/

Three step approach to promoting competition and efficiency in the DDR cleared award

9.17 The introduction of a market-led approach to spectrum management is motivated by our desire to improve efficiency and competition both in the spectrum market itself and in markets for services reliant on spectrum.

9.18 A market-led approach to spectrum management helps to promote competition and efficiency since, when markets work well, they help to reveal information and provide incentives which promote efficiency. Additionally, a market-led approach can help to reduce barriers to entry by reducing restrictions on spectrum use which helps to make spectrum more substitutable, and so promotes more competitive market structures by making new entry easier.

9.19 However, these features of a well functioning market will not always emerge. This is because markets sometimes fail. There are a variety of market failures which can arise when spectrum is managed through a market-led approach, and it is important for us to take these into account, as it is possible to reduce the risk of market failure by adapting the approach to reflect these risks.

9.20 Examples of potential market failures which could have a significant impact upon whether a market-led approach promotes competition and efficiency are provided below:

- In some situations it is possible for the holding of spectrum in particular frequency ranges to be crucial for the provision of goods or services in a particular downstream market. Where ownership of this spectrum is concentrated in a few hands, competitors may be impeded from entering the market for the downstream services, and so the resulting market structure is one in which competition is not promoted fully. The potential competitive advantages of spectrum ownership in this situation, owing to the barrier to entry it represents, may provide a motivation for a party to acquire and hoard spectrum, with the intention purely of denying its use to others, and hence preventing the emergence of a more competitive market structure. These incentives can arise even if the market is not characterised by single or collective dominance (under the tests defined in competition law), but the risk of such behaviour is likely to diminish the more competitive the market and hence the less the market power held by individual market players.

- Secondary trading of spectrum is an important mechanism for parties to optimise their spectrum ownership and use patterns according to market circumstances and in response to technological developments. However, the emergence of efficient spectrum trading depends on the extent to which both current and prospective spectrum owners have relevant information about spectrum in the market and the uses to which it is being or can be put. A lack of relevant publicly available information can result in a market failure which impacts on spectrum efficiency because it impedes price formation, spectrum acquisition and hence efficient spectrum use.

9.21 In the DDR cleared award we have used a three step approach to reducing the risk of market failure. The first step involves using auction design and packaging to try and set the foundations for a well functioning market, and to bring about (where relevant) a market structure that furthers competition. The next two steps in the process involve considering whether or not to impose varying forms of regulatory intervention, to reflect the risk that, given the nature of the spectrum and its uses, it

may not be possible to achieve a well functioning market through appropriate award design alone. In summary, the three steps can be described as follows:

- The first step involves using auction design and packaging to promote competition and efficiency. For example, the auction can be designed in order to help to reveal information which can minimise the ability of participants to behave strategically to manipulate the outcome of the award process. This step can often go a long way towards achieving an outcome where a well functioning market, with a market structure that furthers competition, emerges without imposing significant costs on participants. This is because this approach generally works by removing barriers that may prevent the market from working, but does not involve substituting regulatory decisions for the outcome of the market. However, in some situations, for example, when the spectrum under consideration is particularly valuable and there are limited substitutes, these provisions alone may not be enough to ensure that a well functioning market emerges.

- The second step involves considering whether there is a need for general safeguards to provide spectrum holders with sharper incentives to use spectrum efficiently and to promote competition through bringing about a more competitive market structure. These safeguards would apply to all spectrum holders irrespective of the use to which they put the spectrum. These remedies would generally involve imposing regulatory judgement on the outcome of a market and can impose significant costs if this judgement proved to be incorrect. As a result, we need to consider the costs and benefits of these interventions carefully before deciding to act.

- The third step involves identifying whether there are potential uses to which spectrum could be put which raise specific market failure risks, and identifying whether targeting intervention designed to help to ensure that the award brings about a more competitive market structure would be an appropriate regulatory response to such risks. As with the general remedies mentioned under step two above, remedies imposed to forestall or alter such risks impose regulatory judgement on the outcome of a market, and hence it is important to consider the costs and risks involved to ensure that these do not outweigh the likely benefits of intervention.

9.22 If these steps are either insufficient to remedy any problem, or if, owing to uncertainty over the market outcome, the costs of pre-emptive intervention are too high to justify action, we have general sectoral and competition powers that enable us to address certain competition concerns if they emerge.

9.23 As we discussed earlier, we have a principal duty to promote competition where appropriate, which is a related but nevertheless separate concept to addressing anti-competitive behaviour where it occurs. Our spectrum awards to date have illustrated how auctions can promote competition through allowing new entry and bringing about more competitive market structures. This is one reason why we are potentially concerned about situations where the presence of some level of market power (even in cases where this level of power is below that which would imply dominance) may create the conditions for the award of spectrum (absent intervention) to fail to bring about more competitive market structures. Hence, in summary, given our duty to promote competition, we are concerned by award outcomes, where the likely market structures are less competitive compared with what they were or could have been under different award outcomes. And where these likely market structures result in market players having a degree of market power (even though this does not in itself suggest that a dominant position and anti-competitive behaviour will emerge).

9.24 In the DDR consultation document and statement we carefully considered the risk of the award of the digital dividend resulting in a market failure which might suggest the need for us to depart from a market-led approach, and identified an analytical approach for assessing these issues. This analytical approach involves identifying and trading off the benefits of resolving the market failure with the costs of the intervention and the risks of regulatory failure. In this section we apply this framework to assess the potential for market failures which could impact upon whether the use of the cleared spectrum assigned through auction promotes competition and efficiency. This does not mean that we are re-opening our assessment of whether a market-led approach is the best way to maximise the total value to society generated by the use of the spectrum over time, but recognises that in facilitating markets (i.e. through our auction design) we face choices which impact upon the likelihood of these markets achieving a successful outcome that promotes competition and efficiency, for example, by helping to ensure that (where possible) more competitive market structures emerge.

9.25 In the remainder of this section we apply each of the three steps set out above to the DDR cleared award to identify how best to promote competition and efficiency through this award.

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

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

Step one - using packaging and auction design to promote competition and efficiency

9.26 We consider next how decisions over packaging and auction design can help to create the foundations for a well functioning market that supports the development of competition, and hence, promotes competition and efficiency. We have taken the conclusions of this analysis into account in sections 7 and 8 above.

9.27 In relation to packaging, we considered how this can impact upon possible outcomes of the award process and the consequences for competitive market structures both in the spectrum market itself and associated downstream markets. There are a number of ways in which we can package the spectrum to promote competition and efficiency, for example:

- The number of packages of spectrum each individual bidder can acquire may determine the number of players who can compete in a relevant downstream market. This is because ownership of spectrum in a particular frequency range can, in some situations, be a pre-requisite for entry into a market. In these situations we can influence the amount of spectrum an individual bidder can acquire by packaging spectrum in sufficiently small packages in order that multiple winners can be accommodated.

- We can provide opportunities for the spectrum to support a wide variety of downstream uses by packaging the spectrum in such a way that the spectrum can be used as an input to different downstream markets. Such an approach can

also help to address threshold risks, which can increase competition for the spectrum in the auction.

- Having flexible raster positions where possible can help minimise the amount of unused spectrum at the end of the award process.

- Maximising the number of frequency-generic lot categories can reduce the risks of collusion and strategic bidding, increasing the efficiency of the auction outcome.

9.28 In relation to auction design there are a variety of ways in which this can use used to promote competition and efficiency, for example by:

- maximising the incentives on participants to bid their true value for the spectrum;

- minimising incentives and possibilities for strategic behaviour by bidders aimed at excluding other bidders or reducing prices paid; and

- maximising opportunities to participate and hence facilitate efficient new entry.

9.29 We have taken these into account in identifying our proposed auction format for the cleared spectrum award – a Combinatorial Clock Auction – which includes a number of relevant features designed to assist in the efficient allocation of spectrum and encourage competitive entry. These features are set out in the discussion of the auction rules in section 8 and include:

- The use of a second price rule which encourages bidders to bid their true value for spectrum, because they can be sure that if this is a winning bid, they will have obtained an asset with some level of value to them (equal to their bid less the next highest bid). If bidders were not to bid their true values but instead to shade their bids below their true value, this would risk inefficient outcomes.

- The formulation of activity rules in the primary bid rounds, which help to ensure that bidders cannot hide demand during the auction with the intention of obtaining a strategic advantage over other bidders.

- Rules on bidder association aimed at prohibiting collusive coalitions of bidders, or collusion concerning the bidding process itself.

- The extent to which information about bidders and bids is revealed throughout the auction process. These rules can aid price discovery, by addressing common value uncertainty. However, if too much information is revealed this can increase the risks of collusion or inappropriate tactical bidding or influencing.

- Participation rules and payment processes that aim to enable a wide participation in the award.

9.30 In summary, packaging and auction design can be tailored in order that award outcomes, as far as possible, foster more competitive market structures, and hence help to promote competition and efficiency. Our packaging and auction design for the DDR cleared award includes features such as the use of flexible raster positions and the formulation of activity rules that discourage strategic hiding of demand which, when all taken together, help to promote competition and efficiency. We think these proposals will go a long way towards achieving this goal in the DDR cleared award. However, in the remainder of this section we go on to consider whether further

regulatory action may be required given the importance of this spectrum and its relative scarcity.

Step two - general provisions to promote competition and efficiency

9.31 In this section we consider whether there may be a case for general regulatory remedies to promote further competition and efficiency. These general remedies would apply to all of the potential uses of the cleared spectrum and would seek to sharpen the incentives of spectrum holders to use spectrum efficiently and to promote more competitive market structures. Remedies which we have considered which fall under this heading are:

- Use it or lose it requirements – these would involve using licence conditions to ensure that spectrum licensees do not hold spectrum idle.
- Rollout obligations – these would ensure that spectrum holders rollout services to a certain minimum extent.
- Information provisions – these would work to ensure that there is information available to the market on spectrum holdings, the aim of which is to remove potential barriers to efficient secondary markets.
- Access requirements – these would involve placing conditions in licences that would require spectrum holders to provide access either to the spectrum they hold or to the networks they build using this spectrum in order to further remove barriers to entry, and promote more competitive structures in downstream markets.
- Spectrum caps – these would involve placing limits on the amount of spectrum that any one licensee can hold. The purpose of this would be to ensure that spectrum holdings are not heavily concentrated, and hence more competitive market structures are promoted.

9.32 A number of respondents to the DDR consultation document raised questions around competition issues and some suggested some of the potential remedies mentioned above as solutions.

9.33 We consider below whether there is a case for applying any of these remedies to the DDR cleared award on a general basis (i.e. across all potential spectrum holders). In the next section we then go on to consider whether there are specific market failure risks which may justify more targeted intervention in relation to individual potential uses of the spectrum.

Use it or lose it requirements

9.34 These conditions would be included as conditions in the licences to be awarded. Under them, spectrum owners could be required to give up their rights to spectrum if they were found to be not in use, or alternatively take action to address the underutilisation concerned. This potentially addresses any risk of inefficiency arising from speculative spectrum hoarding or from users holding spectrum idle for other reasons, and this resulting in inefficiency of spectrum use and/or a failure to fully promote competition.

9.35 These conditions might be effective and hence beneficial in situations where it is clear that two conditions were met: that the spectrum was being held idle; and that

such idle holding was inefficient. However, there are a number of drawbacks with these conditions. These include the following:

- It may in practice be difficult to define and so detect where spectrum is used or not. It is likely, for example, that spectrum owners will use their spectrum holdings for some purpose, even if it is not to the fullest extent possible. Additionally, spectrum owners may in any case be able to find ways of circumventing use it or lose it rules by for example finding limited and temporary uses for their spectrum.

- Use it or lose it requirements may foster rather than correct for inefficient spectrum use. In some situations it may be efficient for firms to hold spectrum idle, perhaps for sustained periods. For example, a firm may have judged it better not to use the spectrum while waiting for a particular market uncertainty to be reduced. Forcing spectrum use in such cases might encourage early and inefficient investment in particular services or markets.

- Use it or lose it conditions may also act as a significant barrier to efficient trading, where trading is predicated on a change of use or on a use which requires the spectrum to be unused for a period.

9.36 Taking these considerations into account, we do not propose to introduce use it or lose it requirements into the licences made available in the cleared spectrum award. This is because we think that the benefits of using this remedy are likely to be limited whilst the costs could be significant given the difficulty of detecting when idle spectrum is inefficient, which is particularly likely to be relevant here given the market uncertainty faced by some of the potential users of the cleared spectrum.

Rollout obligations

9.37 These generally involve a licence condition which places an obligation on a licensee to rollout a network and services to cover a defined proportion of the UK population. The purpose of this remedy would be to ensure that coverage is widespread across the UK, even in areas which may not be commercially attractive, in order to ensure both that spectrum is utilised and that citizens in these areas receive benefits.

9.38 As mentioned above, the key purpose of this remedy is to ensure that networks and services are rolled out in areas where it may not be commercially attractive. Therefore, this remedy is likely to impose costs on spectrum holders and hence could make entry commercially unattractive in some situations. Alternatively, if entry still occurs, the remedy forces a cross subsidy which is paid for by other consumers, thus distorting the markets concerned.

9.39 Therefore, this remedy should only be considered when there is evidence that the benefits of the additional rollout which it secures are likely to exceed the costs. However, even in this situation, a rollout obligation may not be the most cost effective approach to achieving the desired level of rollout. For example, where the service could also be provided through other means (i.e. over fixed infrastructure rather than by using spectrum), such obligations risk distorting the provision of the service in a commercial and cost-effective manner, since they may impose additional costs on service providers and hence their wider consumer base. In such situations, as we set out in our DDR statement, a more efficient approach is typically to fund provision of the desired additional services directly, with funding coming from bodies tasked with delivering or procuring relevant public benefits. Such an approach would ensure that the socially desirable level of rollout is achieve while allowing flexibility in how services are provided in different areas; it may be the case for example that different

blends of inputs (spectrum at different frequencies, or different blends of spectrum and fixed infrastructure) deliver the same overall service at lower costs in different areas.

9.40 In the DDR statement we considered whether there was evidence to suggest that a market failure could result from the citizen benefits of additional rollout being ignored by spectrum holders. We did not find evidence to suggest that this form of market failure would occur as a result of the DDR cleared award. Additionally, as discussed above, even if this form of market failure were to occur we do not think that a rollout obligation would be the appropriate remedy, as direct funding can achieve these benefits in a more cost effective manner. Hence, we do not propose to introduce rollout conditions in the spectrum licensees to be awarded.

Information provisions

9.41 The public availability of information regarding spectrum in the market and the uses to which it is being put can be very helpful in enabling existing and prospective spectrum owners to gauge the relative value of spectrum in relation to other inputs and so make efficient purchasing and production decisions, including within secondary markets for spectrum. Currently the availability of this information is relatively limited.

9.42 The scope and nature of information that is most helpful for promoting efficient spectrum use and secondary markets will, at a high level, be concerned with the volumes and frequencies of spectrum awarded and the extent to which it is being used, so enabling a view to be taken on the amount of spectrum which is potentially available for other uses which may emerge in the future.

9.43 In response to concerns about the limited availability of such information, we have decided to include in the 2.6 GHz award[64] a standard condition in the licences for the 2.6 GHz and 2010 MHz bands which requires licensees to provide us, on request, with general information regarding their equipment and use of frequencies, or the rollout of their network. We further noted that we may from time to time publish aggregated information received on the number of base stations and frequencies used in areas across the UK, in order to help secure optimal use of the spectrum and facilitate trading.

9.44 We consider that such an approach could have general merit in respect of the DDR cleared award. The form such a condition might take is discussed in section 6. We think that the costs of the approach are limited. However, we note that in adopting any such approach one concern would be the need to recognise appropriately any commercial confidentiality concerns that the public release of certain data might raise. Conversely, we think that the benefits of the approach are potentially significant. This is because, given the likely importance and scarcity of the cleared spectrum, inefficient spectrum use, even for relatively short periods of time, could impose significant costs on UK citizens and consumers.

Access requirements

9.45 Where the control of spectrum is concentrated in a few hands, with the consequent potential to result in a market structure in which competition could be further promoted, it may be helpful to require spectrum holders to make the spectrum

[64] See http://www.ofcom.org.uk/consult/condocs/2ghzrules/statementim/statement/statement.pdf

available in some manner to third parties; i.e. to impose access requirements. This could in some situations promote downstream competition. Forms of access conditions have been proposed and used for example in the recent auction for 700 MHz spectrum held in the United States of America by the Federal Communications Commission (FCC). The exact form of condition that may be most effective will depend on the circumstances under consideration.

9.46 The manner of access requirements can vary, in that they can be tied to one or more elements of service or asset under the control of the licensee. At a most basic level, access could be given to the spectrum itself, on specified terms. On the other hand, access could be given to services which are provided using spectrum, or to other inputs (apart from spectrum) required for the service. For example, it could involve access to the network, so implicitly including necessary infrastructure such as towers and transmitters, or to wholesale services such as roaming.

9.47 Access conditions can be advantageous when they allow a spectrum auction to arrive at a more efficient outcome even when this might not appear directly to promote competition in downstream markets. This type of situation may arise, for example, when the efficient use of spectrum requires a small number of networks to be deployed and hence the emergence of relatively concentrated market structures at the network level (as the spectrum required per network is large compared to the available spectrum), but when the provision of these services to end users in a downstream markets can efficiently support a larger number of players (i.e. a less concentrated downstream market structure).

9.48 These conditions tend to be most effective where the requirement for downstream access to wholesale services or spectrum is clear cut and where access conditions can be tailored to the circumstances.

9.49 Nevertheless, even in these circumstances, access conditions can be complex to specify and difficult to implement effectively. For example, it may be necessary to specify the terms on which access is to be provided. This requires careful assessment of the costs that the wholesale provider incurs in providing wholesale access and the impact of this on the incentives of the provider to develop or improve services. Terms which are too generous to the downstream players for example could risk unintended consequences such as a relative lack of investment in network services by the wholesale provider.

9.50 Because there are a variety of different uses of the cleared spectrum it is unclear that a general access remedy would be appropriate. This is for the following reasons:

- Given the variety of potential uses of the cleared spectrum, the benefits of this remedy used in a general way are hard to see; it is not at all clear that one form of access requirement would facilitate all possible types of downstream competition. Conversely, the costs and unintended consequences of this approach might be significant; onerous or inappropriate access conditions could distort interest and the market for spectrum.

- Access conditions are generally more suitable for facilitating competitive downstream market structures in specific situations (when the terms of access can be tailored to the particular problem). This is because access conditions may be expected to be more effective where they are targeted at specific issues when there is a clear cut case for downstream market players to be provided access to the wholesale services afforded through use of spectrum.

9.51 Overall we do not think there is a case for applying a general access condition to all of the potential uses of the cleared spectrum. Access conditions can have significant unintended consequences, and hence should only be applied when there is a strong case for access being required to further promote competition or efficiency. There is no such requirement which applies generally to all of the potential uses of the cleared spectrum. There is sufficient spectrum in the DDR cleared award to support a variety of different uses, and for each of these uses, to support varying numbers of individually users. Therefore we think that the benefits of general access conditions, which apply to all uses, are limited and the costs are potentially significant.

Spectrum caps

9.52 Spectrum caps work by limiting the amount of spectrum that an individual party may hold. Their purpose is to promote diversity of spectrum holdings, and hence facilitate the emergence of more competitive market structures which can help to foster efficient spectrum use.

9.53 We set out below the forms spectrum caps might take, whether or not there might be a case for applying a general spectrum cap in respect of cleared spectrum, the advantages and disadvantages of this approach, and our conclusions.

9.54 Spectrum caps can take a variety of different forms:

- Spectrum caps can be set as an absolute limit on the amount of spectrum any one party can hold (i.e. a hard spectrum cap), or can be set such that if the cap is exceeded, there are other conditions which may apply to the spectrum licence such as a different initial licence period (i.e. a soft spectrum cap).

- Spectrum caps can be set either loosely or tightly. A loose spectrum cap involves setting a cap at such a level that it has only limited impact on the uses to which the spectrum can be put by an individual party, but with the intention of being a general safeguard to prevent spectrum holdings becoming heavily concentrated. A tight spectrum cap aims at constraining the structure of spectrum holdings and use more severely, and might be used where there are significant concerns that absent such caps there is a likelihood that more competitive market structures might fail to arise.

- Spectrum caps can either be set without reference to other spectrum holdings or can be set to take into account spectrum holdings across other spectrum bands. In this discussion we call the first type ‘non-contingent’ caps and the second type ‘contingent’ caps.

- Finally spectrum caps might be set to apply at the time of the award of spectrum only (e.g. each bidder in the auction might be restricted to a maximum purchase level) with no restriction on subsequent secondary market trades and holdings. Alternatively they might be set at the time of the award and endure afterwards.

9.55 Benefits of spectrum caps include that are relatively simple to understand and implement. They are also likely to be effective in promoting a diversity of spectrum holdings and more competitive market structures both in the general sense and where a more targeted approach is required.

9.56 However for these benefits to be realised without undue costs requires careful judgement about the size and nature of the spectrum cap. Inappropriately tight caps for example risk eliminating spectrum award outcomes that would otherwise have

been efficient. Given the size and nature of potential consumer and citizen benefits from spectrum use, the costs of any such distorted outcomes could be very significant. Alternatively inappropriately loose caps risk failing to have an effect and so failing to promote sufficiently more competitive market structures.

9.57 The nature of the cap which may be appropriate, and its costs and benefits, will depend upon the competition and efficiency considerations to be addressed by the remedy. The following paragraphs consider whether there may be a case in the DDR cleared award for a spectrum cap to be applied as a general remedy.

9.58 The benefit of such a cap is that it would promote diversity of spectrum holdings. Diversity can be a desirable outcome of the auction as it may help to promote more competitive market structures. A cap in the auction may promote such diversity without targeting particular types of use. This is of particular relevance given our proposal for the DDR cleared award for licences to be service and technology neutral, where the range of services to be deployed is uncertain, but where the available spectrum is relatively scarce. This type of remedy would also prevent a speculative bidder acquiring a large amount of spectrum, which it could then decide to hold idle with a potential impact on efficiency and competition.

9.59 Additionally, we think that it would be possible to introduce a general cap without unreasonably constraining the potential uses of the cleared spectrum, and hence without imposing significant costs. That is because we can be sufficiently confident that no one user needs substantially all of the spectrum.

9.60 We think that there may therefore be a case for a general cap in the DDR cleared award. This would be a hard cap, in that it would provide an absolute limit on the amount of spectrum any one party can acquire at the auction. It would be a non-contingent cap that only applied at the time of the award, in that it would only limit the amount of spectrum which could be acquired in the DDR cleared award at the time of the award, after the award individual licensees (including speculative licensees) could build larger holdings via the secondary market if this represented the most efficient market outcome.

9.61 We have also given consideration to the level at which we should set the general safeguard cap. The size of the cap in the DDR cleared award would need to be set in the context of the potential uses of the spectrum and the amount of spectrum available. Of the likely uses, we note that the creation of a national multiplex for broadcasting would typically require at most around 48 MHz, while those requiring licences for mobile broadband applications could be interested in acquiring up to around 40 MHz (i.e. 2 x 20 MHz). Set against a total availability of 144 MHz in the DDR cleared award, of which 120 MHz will be available for national medium or high power use (48 MHz in the upper sub-band and 72 MHz in the lower sub-band), this would suggest that a spectrum cap of 50 MHz could be appropriate (which would amount to just over 40% of the national cleared spectrum available). We believe that a cap set at this level would not unduly constrain any one use whilst still promoting diversity of spectrum holdings.

9.62 Furthermore we note that such an approach would be consistent with our approach for the 2.6 GHz award. There we have, for similar reasons, decided to apply an 80 MHz safeguard cap to the amount of spectrum which any one bidder in the award can win, representing just under 40% of the total 205 MHz of the 2.6 GHz spectrum available for award.

9.63 In summary, we think that there may be a case for a general safeguard cap in the DDR cleared award, set at the level of 50 MHz. This cap would apply at the time of the award only, and would only apply to spectrum in the DDR cleared award. The key benefit of the cap would be to ensure that spectrum holdings are sufficiently diversified following the award and hence more competitive market structures are promoted. We think that this is important given the importance and scarcity of this spectrum. Given the availability of spectrum, and the likely requirements of the different uses, we think that a 50 MHz cap would impose limited costs.

Summary of first two steps to promoting competition and efficiency in the DDR cleared award

9.64 Therefore in summary the first two steps in our approach to promoting competition and efficiency in the award and use of the cleared spectrum have resulted in the following:

- We are proposing to use auction design and packaging as the starting point for the promotion of competition and efficiency. Our proposals for packaging and auction design were set out in sections 7 and 8 respectively.

- We are also proposing to apply a loose spectrum cap (at approximately 50 MHz) on the acquisition of cleared spectrum in the auction. This is a safeguard cap which would apply generally to all licences awarded in the cleared spectrum award, and would not apply to subsequent licence holdings. Section 8, which sets out our approach on auction design, notes that it will be necessary to consider how to implement such a cap, for example through the appropriate design of eligibility rules.

- We are also proposing an information provision licence condition which aims to put into the public domain information about spectrum ownership and use in order to facilitate secondary trading; we have discussed the issues affecting the detailed drafting of such a condition in section 6.

- We are not proposing use it or lose it, rollout conditions, or general access conditions.

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

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

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

9.65 In the next section we consider whether there are specific market failure risks which might require us to take tailored action in relation to any particular potential use of the cleared spectrum.

Step three - specific issues considered by the competition and efficiency assessment

9.66 We set out here the process we have followed in analysing and identifying particular competition and efficiency considerations that might arise as a result of particular outcomes of the cleared spectrum award which have the potential to result in market structures which, if we had intervened, could be more competitive (i.e. which fail to fully promote competition). Where these situations are identified we think they merit specific consideration as they may require intervention above and beyond that given by packaging and auction design and the more general remedies discussed under steps 2 and 3 respectively.

9.67 Our analysis has focused on three broad downstream markets: broadcasting, mobile broadband, and mobile multimedia. As discussed in section 4, and in our earlier DDR documents, these encompass the most likely potential uses of the spectrum.

9.68 For each broad downstream market, we considered a wide range of spectrum award outcomes in order to assess the likelihood and significance of market structures emerging, absent intervention, that may fail to fully promote competition, and the significance of such an outcome for consumers and the competitive process more generally.

9.69 Our assessment was forward looking and necessarily to some extent speculative. All three downstream markets are rapidly developing and subject to a considerable degree of uncertainty. Any intervention or remedy posited in order to promote more competitive market structures will carry its own risks and/or costs. This means that we need to be careful when identifying market structures which could in principle be more competitive and, when we do identify such outcomes, in proposing any remedies for them.

9.70 For this reason, our analysis has sought to focus on outcomes where the potential market structure could be more competitive, and where, if this were the case, consumer benefits could be significantly higher. For these outcomes we have gone on to consider whether there are available remedies which can promote more competitive market structures without imposing unreasonable costs. However, we note that we might be prepared to accept a higher cost or risk from the remedy if this is likely to promote a significantly more competitive market structure. We have also considered the extent to which competition considerations attached to certain spectrum award outcomes might better be addressed in ways other than intervening in the spectrum award itself.

9.71 In identifying outcomes where we could help to bring about a more competitive market structure if we were to intervene further, we have given particular attention to markets where we are aware of recent and/or ongoing analysis in relation to whether the current (or likely future) market structure is consistent with the promotion of competition.

9.72 The table below sets out the full set of issues we have considered and highlights three issues which we identified as sufficiently likely to result in a market structure which may fail to fully promote competition as to require consideration of possible remedies in the DDR cleared award.

Table 9.1 Scenarios considered to identify outcomes when the market structure could be more competitive

Description of possible spectrum award outcome	Potential impact on market structure	Analysis
Broadcasting		
Sky purchase of cleared spectrum for pay TV services	- If Sky were found to have market power in premium pay TV and related markets, then this could create the potential for an acquisition by Sky of DDR spectrum to potentially foreclose the development of more competitive market structures, for example by limiting the ability of other competitors to access terrestrial broadcasting capacity	- The Pay TV market investigation consultation document[65] set out concerns regarding effective competition in the pay TV industry. Given this we think that we need to consider carefully the potential for Sky to acquire DDR spectrum in order to identify whether, because of Sky's market position, this could impact on the promotion of competition or efficiency as a result of the award of the cleared spectrum (i.e. whether this could result in a market structure which could be more competitive) - Therefore, **this issue is considered further below**
ITV acquisition of cleared spectrum to deploy additional DTT multiplex(es)	- Could potentially allow ITV to strengthen its position in the national TV advertising market	- Given the presence of the Contract Rights Renewal (CRR) remedy, and given the current OFT/Ofcom review[66] of this remedy, **we do not think this issue is sufficiently significant to warrant consideration of separate action in the award of the cleared spectrum**
NGW/Arqiva acquire cleared spectrum to deploy additional DTT multiplex(es)	- Spectrum acquisition could potentially result in a player with a greater degree of market power over the DTT multiplex capacity market in addition to market power over	- We consider that this is an issue that requires careful consideration - Therefore, **this issue is considered further below**

[65] See http://www.ofcom.org.uk/consult/condocs/market_invest_paytv
[66] See http://www.oft.gov.uk/advice_and_resources/resource_base/register-orders-undertakings/reviews/CRR-review

	upstream services (i.e. managed transmission services) and as a result more competitive market structures may have been precluded	
PSBs (other than ITV) purchase cleared spectrum to deploy additional DTT multiplex(es)	- Could increase their market share in terms of DTT capacity - Has the potential to exclude new entrants, and other downstream broadcasters, and hence fail to result in a more competitive market structure	- There is little evidence to suggest that the PSBs acquisition of cleared spectrum would preclude better market structures arising, and for this to have resulted in significantly lower benefits for consumers than would otherwise be the case - **We do not think this issue is sufficiently significant to warrant consideration of separate action in the award of the cleared spectrum**
Mobile broadband		
Cleared spectrum is purchased to provide a 3G or Next Generation Mobile (NGM) network (i.e. LTE or WiMAX)	- The advantages of low frequency spectrum, combined with its limited availability for these services, limits the number of networks that can be deployed using these frequencies - As a result, the market structure which emerges may be one in which the acquirer(s) of the cleared spectrum suitable for mobile broadband have a potentially stronger market position than other potential players in this market	- We consider that this is an issue that requires careful consideration - Therefore, **this issue is considered further below**
Mobile Multimedia Services (MMS)		
A Mobile Network Operator (MNO) (or a consortium of MNOs) purchases cleared spectrum in order to provide network for	- Potential to establish market structures which are less competitive than they could otherwise have	- The availability of substitute spectrum and possibilities for consumers to access mobile broadcast and other content through other means (e.g. content download on 3G) means the

own MMS service, or to provide a wholesale network service	been (i.e. could result in a vertically integrated monopoly in the provision of MMS services at either the retail or wholesale level, at least in short term);	market structure is unlikely to be determined by the outcome of the DDR cleared award, and that sufficiently competitive market structures are relatively likely to emerge **- We do not think this issue is sufficiently significant to warrant consideration of separate action in the award of the cleared spectrum**
A broadcaster purchases cleared spectrum in order to provide own use end-to-end MMS service	- Broadcaster control of content has the potential to allow a market structure to emerge in which competition is not fully promoted	
A broadcaster purchases cleared spectrum in order to operate a network and to provide a wholesale network services to other MMS providers	- Broadcaster has the potential to establish a strong market position in the wholesale provision of MMS network services, and this precludes the development of more competitive market structures	

9.73 The high level summary of our assessment of possible spectrum award outcomes and the potential for these to result market structures which could be more competitive highlights that, in most cases, we concluded that any concerns about the likely market structure were not sufficiently significant to warrant further consideration.

9.74 However, our assessment identified three particular issues for which we consider that there is sufficient potential for the market structure to be less competitive than it might otherwise have been. In relation to these issues we think further investigation is required in order to identify whether targeted intervention in the DDR cleared award may be warranted. These issues, which are considered in the following paragraphs, are:

- Mobile broadband – availability of low frequency spectrum for mobile use;
- Pay TV – Sky acquisition of cleared spectrum for pay services on DTT; and
- NGW/Arqiva – acquisition of cleared spectrum for additional multiplexes on DTT.

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

Sub 1 GHz spectrum for mobile broadband

9.75 As noted in section 4 above, there is increasing interest in the suitability of cleared spectrum for mobile broadband applications and this has attracted attention from amongst others, existing mobile network operators. The cleared spectrum could offer

advantages in terms of building penetration and coverage as compared with higher frequency spectrum. Owing to the prospect of non-mandatory harmonisation of the upper sub band (790 to 862 MHz) for mobile broadband use in some European countries, this sub band may become particularly valuable for the deployment of mobile networks in Europe.

9.76 One likely candidate for mobile use of this spectrum would be as part of the deployment of Next Generation Mobile Networks (NGM), such as Long Term Evolution (LTE) or WiMAX. These are mobile broadband networks that support significantly increased data transfer rates and reduced latency compared with existing 3G services. These technologies can be deployed in a variety of different band widths (i.e. LTE can be deployed using spectrum blocks which range from 1.25 MHz to 20 MHz) but for the benefits of the higher data rates to be achieved larger spectrum blocks (i.e. 2x10 or more of contiguous spectrum) may well be needed.

9.77 Given these spectrum requirements, there are likely to be significant constraints on the number of NGM networks which could efficiently be supported using the cleared spectrum. For example, if bidders were to acquire 2x10 MHz of contiguous spectrum each, the upper sub band may only support the deployment of two such networks.

9.78 We therefore believe that there is a plausible, but not certain outcome, in which any networks which are deployed using the cleared spectrum have a competitive advantage over networks which may be deployed using only other, significantly higher frequencies, and hence as a result the emerging market structure could be less competitive than it would otherwise have been. This is due to the physical properties of spectrum which can mean that high quality coverage for high data rate services is more costly to achieve the higher the frequencies used. We consider that this could limit the intensity of competition between mobile networks which have access to different frequencies in future.

9.79 Such an outcome might occur if:

- any NGM networks deployed in the cleared spectrum use a large proportion of the available spectrum, and hence the number of networks which can be deployed is limited; and

- access to low frequency spectrum provides a competitive advantage in the provision of high quality, high data rate services as compared with networks which are deployed using only higher frequencies.

9.80 If these two outcomes arise, and the provision of high quality, high data rate services matters to consumers, the effect on the resulting market structure and hence on the degree of competition possible in the future mobile sector could be significant.

9.81 We believe that further consideration of these issues is required, and are interested in stakeholder views on the likelihood and significance of this potential issue.

Question 42: Do you agree with our assessment that the limitations on the amount of cleared spectrum available for mobile broadband applications, and the particular advantages of sub 1GHz spectrum, could result in an outcome where there are limits on the level of competition possible in the provision of these services?

9.82 There are a number of potential mitigating factors which could reduce the significance of the potential market structure effect discussed above.

9.83 For example, it may be possible for future mobile broadband networks using the 900 MHz band to compete with NGM networks using the cleared spectrum. The spectrum in the 900 MHz band is likely to offer similar advantages to the cleared spectrum in terms of the ability to achieve high levels of coverage at lower cost compared to higher frequencies. However the amount of spectrum available at 900 MHz is also limited, and is already being used to provide 2G mobile services.

9.84 An alternative mitigating factor would be if any NGM networks deployed using the cleared spectrum provided access to other operators, such that operators who have deployed networks at higher frequencies are also able to gain access to the benefits of high quality coverage at reasonable cost.

9.85 These two factors suggest that, if we were concerned about the scale of the potential competition effect which could arise from the limited number of networks which it may be possible to deploy in the cleared spectrum, there are two potential options for addressing this issue.

9.86 The first is a spectrum cap which ensures that ownership of sub 1GHz spectrum suitable for mobile use (principally the cleared upper sub band and the 900 MHz spectrum) is sufficiently widely distributed. The second would be access conditions which ensured that the benefits of low frequency spectrum were available to sufficient operators in the market. And of course it might also be possible to combine these two approaches in some way.

9.87 A limit or cap on spectrum holdings to resolve a competition concern could take a number of forms. For example, this could involve a limit on the spectrum that any one party may purchase in the DDR cleared award (irrespective of their existing spectrum holdings i.e. a non-contingent cap), or a limit which was contingent on current holdings of other sub 1GHz spectrum (such as 900 MHz spectrum). In either case the amounts permitted would need to be linked in some manner to our view on the amount of spectrum required to rollout an NGM network efficiently.

9.88 Such a cap need not necessarily be ‘hard’ in the sense of an absolute bar on the amount of spectrum that can be held. We see some merit instead in setting an enduring ‘soft’ cap which, if exceeded, triggers particular licence conditions. Such conditions could take a number of forms, all aimed at addressing the perceived competition concern. However, a particularly straightforward condition would be to reserve the right to take back any spectrum in excess of the cap throughout the licence term, even during the initial period when Ofcom’s powers of revocation would otherwise be limited, if a significant competition concern were identified and the relevant party could not satisfy us that the concern was being adequately addressed.

9.89 Such an approach would in the first instance tend to promote competition through promoting diversity in holdings of the spectrum and hence more competitive market structures. Therefore, this approach would seek to resolve the competition concern at the time of the award and hence minimise the requirement for on-going regulatory intervention. However, spectrum caps are not without risk. The key risks of the approach include setting the level of the cap either too low, and so tending to eliminate possibilities for efficient scale size, or too high, and so tending to limit effective competition.

9.90 Similarly access could work in a variety of different ways, for example, operators could provide different levels of access (i.e. this could involve access to spectrum only, access to both spectrum and the network which is deployed, or alternatively could involve the provision of wholesale services such as roaming). The nature of the

access provided, and the conditions under which it is provided, would determine the degree to which it solved any competition concern which was identified. The closer that access is provided to the underlying asset which is required to allow more competitive market structures (i.e. the closer the access is to the spectrum layer), the more effective it is likely to be in resolving the concerns, as this would give those operators who are obtaining access greater freedom to innovate and develop their own service offerings. At the same time it is important that any access condition does not undermine efficient use of the spectrum, for example by requiring excessive coordination or allowing inefficient interference.

9.91 The key advantages of access conditions are that they can foster competitive downstream market structures even where there are upstream bottlenecks on key inputs (i.e. spectrum). The key disadvantage is that the terms on which such access is offered may need to be carefully determined in order that downstream providers did indeed obtain appropriate access, but also that incentives on the provider to make the initial purchase, provide services, and invest in its network were not unduly distorted.

9.92 Overall, we believe that a 'soft' enduring spectrum cap approach is likely to be the most effective form of remedy to competition concerns in this case. This is because the 'soft' nature of the cap would leave flexibility to act in the future only in the event that the cap had been breached and that this had an effect on competition. This could be expected to minimise any distortions the prospect of a cap may have on bidders (or potential bidders) in the primary award. However, we recognise that given the type of cap proposed, we would need to consider carefully the definition of the cap (i.e. the spectrum it applies to and the conditions it triggers) to ensure that it does not preclude otherwise efficient outcomes.

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

Sky on DTT

9.93 In this section we consider whether a potential acquisition of cleared spectrum by Sky in order to launch pay TV services on the DTT platform could result in a market structure which fails to fully promote competition. Within the last year we have published two consultation documents which are relevant to this assessment. These are firstly, the Pay TV market investigation[67] and secondly, our assessment[68] of Sky's proposal to remove the three free to air channels that it currently provides on the DTT platform and replace them with pay TV channels (often known as Sky's 'Picnic' proposal). We have not reached definitive conclusions on the issues considered in either of these documents, which acknowledge competition concerns raised at various levels of the supply chain for pay TV services. However, our analysis here takes into account the issues identified in these documents in relation to the potential for Sky to have market power, primarily in relation to the potential existence of any wholesale markets for premium content (likely to include first run Hollywood movies and particular types of sports content), and the possibility for this

[67] See http://www.ofcom.org.uk/consult/condocs/market_invest_paytv
[68] See http://www.ofcom.org.uk/consult/condocs/dtv/

market power, if it exists, to be leveraged into other markets, and as a result for the potential for more competitive market structures to be forgone.

9.94 If Sky does have market power over wholesale markets for access to premium content, then it is possible that a potential acquisition of digital dividend spectrum by Sky, coupled with this control of premium content, could raise competition concerns such as:

- the potential to foreclose further development of competition in terrestrial broadcasting; and
- the potential to leverage any possible market power arising from control of premium content into retail markets across platforms.

9.95 Both of these effects, were they to occur, could prevent the emergence of more competitive market structures and might not further the interests of consumers. However, in order to assess whether these effects raise a competition concern which we should seek to address through the DDR cleared award, we need to consider carefully the source of the concern.

9.96 A key driver of the concern is, as highlighted above, the extent to which Sky has control over any wholesale markets for access to premium content. The less access that other providers have to such premium content, all other things being equal, the greater the extent that Sky may be able to act independently in terms of pricing and leverage in pay TV markets across all platforms, including any established through the creation of one or more further DTT multiplexes using the cleared spectrum. However, this concern is not directly linked to the impact of a potential acquisition of cleared spectrum by Sky and its result on the market structure which emerges.

9.97 A second relevant driver is the extent to which, were Sky to rollout a further DTT multiplex to offer its services, other pay TV participants or potential entrants might have access to other DTT capacity and so be able to bring about more competitive market structures. We note that some potential exists for the digital dividend to yield more than one multiplex. Additionally, there is the potential for existing capacity on the DTT platform to be upgraded and expanded in the future. To the extent that such capacity is offered to market by the existing DTT multiplex operators on a comparable timescale to Sky's potential acquisition of digital dividend spectrum, other pay TV market participants or potential new entrants could also use this to enter the platform and act as a competitive constraint at that point. However, it may be the case that Sky's market position in relation to premium content could limit the ability of new entrants to compete effectively through either of these routes.

9.98 Overall, we see the question of access to premium content as the central issue in relation to the potential for there to be competition concerns arising in relation to Sky's market position. This issue is not primarily linked to the potential for Sky to acquire cleared spectrum, or to the impact this might have on market structure. To the extent that other issues have been raised regarding competition concerns in the provision of pay TV services, we similarly do not believe that these would suggest a case for intervention in relation to the potential for Sky to acquire cleared spectrum. This would suggest that any competition concerns are best pursued through our existing initiatives concerning 'Picnic' and our wider review of the pay TV market. However, we recognise that we may need to keep this under review.

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

NGW / Arqiva

9.99 The cleared spectrum could be used to rollout additional DTT multiplexes, which could be used to provide wholesale multiplex capacity services. Competition in the provision of wholesale services on the DTT platform is an issue which was considered briefly in the context of the acquisition by Arqiva's owner Macquarie of NGW. Here we consider the potential impact of the merged entity acquiring cleared spectrum in order to create and operate additional DTT multiplexes, and as a result, increasing its market share at the multiplex layer in the value chain and hence impacting on the resulting market structure.

9.100 The main elements of the DTT supply chain are set out in the table below.

Table 9.2 DTT supply chain

<table>
<tr><th>Value chain layer</th><th>Description of the services provided</th></tr>
<tr><td colspan="2">Transmission provider – In relation to DTT NGW and Arqiva provide all Managed Transmission Services (MTS) and Network Access (NA)</td><td>MTS - a package of services including some or all of network design, procurement and installation of transmitters, network monitoring, quality assurance of the signal and maintenance of the transmission equipment and procurement of NA.</td></tr>
<tr><td colspan="2"></td><td>NA - a package of services as defined as providing access to transmission sites and infrastructure including masts, antenna, combining units (if required), on site buildings and access to utility services. NA contracts can include the design and installation of specific equipment including new antenna</td></tr>
<tr><td colspan="2">Multiplex owners – there are currently six multiplexes operated by the following organisations:</td><td rowspan="3">DTT is delivered by multiplexing a set of channels that are then broadcast over relevant spectrum in UHF Bands IV and V. There are six existing multiplexes.

One of these (multiplex 1) has been allocated by the Government to the BBC under its Charter Agreement.

The remainder are licensed by Ofcom to the corresponding licensee. Each multiplex operator (licensee) therefore in principle acts as a gate keeper to spectrum currently necessary for DTT.

Multiplex owners acquire MTS from a transmission provider (who in turn will need to ensure they have appropriate NA Agreements with the site owner)</td></tr>
<tr><td>Multiplex</td><td>Licensee</td></tr>
<tr><td>1
2

A
B
C
D</td><td>BBC
Digital 3&4 (ITV/Channel 4)
SDN (ITV)
BBC Free to view Ltd
NGW
NGW</td></tr>
<tr><td colspan="2">Broadcaster – there are currently in the region of 35 television</td><td>Broadcasters acquire multiplex capacity from multiplex operators. Their services include</td></tr>
</table>

channels broadcast over the DTT platform	capacity on a multiplex which is broadcast from a number of transmission sites.
Viewer reception – there are in the region of 17 million TV sets capable of receiving DTT services	Viewers access the channels broadcast over the DTT multiplex through an aerial and a digital ready television (IDTV) or a set-top box, which decodes the services

9.101 As indicated in the table above, both MTS, excluding spectrum, and NA are subject to ownership and control by Arqiva and NGW. In April 2007, Arqiva's owner Macquarie UK Broadcast Ventures Limited acquired NGW.

9.102 In view of possible competition concerns arising from this, the completed acquisition was referred to the Competition Commission (CC) in August 2007. The CC found, among other things, that the acquisition could be expected to lead to a substantial lessening of competition in the provision of MTS/NA services. After consideration of relevant potential costs and benefits of the acquisition, the CC in March 2008[69] approved the acquisition, subject to the successful negotiation of a number of behavioural undertakings. If undertakings are not agreed, a partial divestment is likely to be required. In the meantime NGW operates as a separate economic entity under hold-separate undertakings.

9.103 At the platform layer, as indicated above, there are six multiplexes which are ultimately controlled by four different parties (the BBC, Digital 3&4 (joint venture between ITV, Channel 4), SDN (owned by ITV plc) and NGW). Three of these multiplexes (A, C, D) are referred to as 'commercial multiplexes'; that is, their multiplex operators do not carry any public service content and are not under any regulatory requirements to achieve specific levels of coverage. The capacity on these multiplexes is therefore available to parties interested in purchasing services. These operators are required to make this capacity available on fair, reasonable and non-discriminatory terms. The other three multiplexes (1, 2 and B) are referred to as 'PSB multiplexes' and have an obligation to match the coverage of the existing analogue terrestrial networks (estimated as being 98.5% of UK households) are used to carry PSB channels. Therefore, NGW currently controls two out of the three multiplexes used to provide services to non-PSB broadcasters.

9.104 A plausible scenario that could arise as a result of the DDR cleared award is the acquisition by the merged NGW/Arqiva of spectrum for use for one or more further commercial DTT multiplexes. This could increase the share this entity has of the provision of multiplex services to commercial broadcasters from two out of three to three out of four or greater.

9.105 However, the impact of this will depend upon whether other wholesale broadcasting services – either multiplex capacity provided on PSB multiplexes, or wholesale platform services provided on other technology platforms - compete with those offered by NGW/Arqiva. For example, a party seeking broadcast services might in principle be able to find other entities who can provide these services, either via alternative access to terrestrial DTT platform through PSB multiplexes, or through

[69] See Competition Commission's final report at http://www.competition-commission.org.uk/rep_pub/reports/2008/fulltext/537.pdf

broadcast services provided on other technology platforms. Both routes might ensure more competitive market structure to emerge even in the case where NGW/Arqiva had increased its share of commercial multiplex capacity.

9.106 It is not therefore clear to us that such an acquisition of cleared spectrum by NGW/Arqiva would result directly in a market structure in which competition is not duly promoted. And even if we were to have such concerns, these would need to be set in the context of the costs and risks of any effective remedies.

9.107 If there were to be significant competition concerns, an effective remedy implemented through the DDR cleared award would be to prohibit the acquisition of digital dividend spectrum. We think this form of remedy would be undesirable as it would have a number of possible unintended consequences such as:

- the loss of opportunities the acquisition might afford for economies of scale or scope; and

- a missed opportunity to allow enhanced coordination abilities. An additional multiplex may give NGW/Arqiva an improved ability to coordinate fully and efficiently decisions, when decisions are required at the level of part or all of the DTT platform (i.e. when deciding upon whether and/or how to upgrade further or expand the platform).

9.108 Given the uncertainty over whether a competition concern would arise (i.e. whether a market structure which fails to fully promote competition could emerege) and the significant risks involved in seeking to remedy this through the DDR cleared award, we take the view at this stage that it would be both disproportionate and create risks of unintended consequences if we were to intervene further in relation to the potential for NGW/Arqiva to acquire cleared spectrum. As a separate issue, we note that in the case that any anti-competitive behaviour were to arise, we would be able to seek to resolve this through our regulatory or competition powers as appropriate.

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

Conclusions

9.109 In this section we have explained why it is important to consider the impact of the DDR cleared award on competition and efficiency in downstream markets, and how our approach to the award aims at achieving this goal.

9.110 Our starting point for promoting competition and efficiency is to use the primary award process (i.e. packaging and auction design) to for example, maximise the incentives on participants to bid their true value for the spectrum, minimise incentives and possibilities for strategic behaviour by bidders aimed at excluding other bidders or reducing prices paid, and maximise opportunities to participate and hence facilitate efficient new entry.

9.111 In addition, we have considered whether there is a case for general remedies which could further promote competition and efficiency. After considering the following remedies: use it or lose it requirements, rollout obligations, information provisions, access requirements, and spectrum caps, we have reached the initial view that:

- in order to promote diversity of spectrum holdings, and hence more competitive market structures, we should impose a general safeguard cap that limits the amount of spectrum any one player might hold as a result of the award process to 50 MHz; and

- in order to promote opportunities for secondary trading, and hence efficient spectrum use, we should facilitate the provision of information concerning spectrum ownership and use by imposing an information provision licence condition.

9.112 We have also considered a number of specific market failure risks where we felt that the award outcome had the potential to result in a market structure which may not fully promote competition. These outcomes included:

- the potential for the limited availability of cleared spectrum for mobile broadband to limit the number of NGM networks which can be deployed using this spectrum;

- the potential for Sky to purchase cleared spectrum to rollout a DTT multiplex and to use this to enter the terrestrial broadcasting market, and the potential for this to have a resulting impact on the emergence of more competition in broadcasting markets, and

- the potential for NGW/Arqiva to purchase cleared spectrum in order to rollout an additional DTT multiplex, and the potential for this to increase its share of the provision of wholesale multiplex services.

9.113 Overall we consider that the DDR cleared award could raise competition concerns for the mobile broadband market. This is because there is a plausible, but not certain outcome, in which any networks which are deployed using the cleared spectrum have a competitive advantage over networks which may be deployed using only other, significantly higher frequencies. This is due to the physical properties of spectrum which can mean that high quality coverage for high data rate services is more costly to achieve the higher the frequencies used. We consider that this could limit the intensity of competition between mobile networks which have access to different frequencies in future.

9.114 In response to this issue our initial view is that there may be a case for capping, in some form, the amount of sub 1GHz spectrum suitable for mobile broadband use which any one party can hold. Such a cap could help to ensure a more competitive market structure in the future mobile broadband market. Such a cap need not necessarily be ‘hard’ in the sense of an absolute bar on the volume of spectrum that can be purchased or held. We see some merit instead in setting a cap which, if exceeded, triggers particular licence conditions. Such conditions could take a number of forms, all aimed at addressing the perceived competition issue. A particularly straightforward condition would be to retain the right to take back the spectrum during the full licence term (rather than have a minimum term during which this right is curtailed) unless the relevant parties could satisfy us that any competition concerns which had been identified were being appropriately addressed.

9.115 We do not at this stage believe that the potential purchase of cleared spectrum by Sky or NGW/Arqiva, in order to operate one or more DTT multiplexes, raise issues that should be addressed through the DDR cleared award.

Section 10

Next steps

10.1 This consultation, published on Friday 6 June 2008, lasts for a 10 week period. The closing date for responses is Friday 15 August 2008. See Annex 1 for details of how to respond to this consultation.

10.2 The proposals for the cleared spectrum award set out in this document raise a number of complex issues, particularly in relation to the technical licence conditions in section 5 and the associated packaging and auction design proposals in sections 7 and 8. Based on previous award experience, stakeholder responses to our proposals may lead us to refine them, and to consult over any material revisions before finalising them.

10.3 We have therefore made provision in our timetable for a follow-up consultation over these technical and more detailed areas later this year if required, before finalising our Statement and draft regulations in early 2009. The DDR cleared award would still begin in Summer 2009.

10.4 Following the closure of the period for receipt of responses to this consultation, we will undertake a comprehensive review of responses and factor this into our decision on the best way to progress this award in a timely and orderly fashion. We will then confirm next steps.

10.5 The table below sets out our current timetable for holding the award of the DDR cleared spectrum

May 2008	First consultation on detailed award design
Summer 2008	First consultation closes
Late autumn 2008	Second consultation on detailed award design
Winter 2008	Second consultation closes
Late spring 2009	Information memorandum and draft regulations
Summer 2009	Award begins

Annex 1

Responding to this consultation

How to respond

A1.1 Ofcom invites written views and comments on the issues raised in this document, to be made **by 5pm on 15 August 2008**.

A1.2 Ofcom strongly prefers to receive responses using the online web form at http://www.ofcom.org.uk/consult/condocs/clearedaward/howtorespond/form, as this helps us to process the responses quickly and efficiently. We would also be grateful if you could assist us by completing a response cover sheet (see Annex 3), to indicate whether or not there are confidentiality issues. This response coversheet is incorporated into the online web form questionnaire.

A1.3 For larger consultation responses - particularly those with supporting charts, tables or other data - please email ddr.cleared@ofcom.org.uk attaching your response in Microsoft Word format, together with a consultation response coversheet.

A1.4 Responses may alternatively be posted to the address below, marked with the title of the consultation:

DDR Cleared Award Project Team
Spectrum Policy Group, Ofcom
3rd Floor
Riverside House
2A Southwark Bridge Road
London SE1 9HA

A1.5 Note that we do not need a hard copy in addition to an electronic version. Ofcom will acknowledge receipt of responses if they are submitted using the online web form but not otherwise.

A1.6 It would be helpful if your response could include direct answers to the questions asked in this document, which are listed together at Annex 4. It would also help if you can explain why you hold your views and how Ofcom's proposals would impact on you.

Further information

A1.7 If you want to discuss the issues and questions raised in this consultation, or need advice on the appropriate form of response, please contact Reuben Braddock on 020 7981 3108.

Confidentiality

A1.8 We believe it is important for everyone interested in an issue to see the views expressed by consultation respondents. We will therefore usually publish all responses on our website, www.ofcom.org.uk, ideally on receipt. If you think your response should be kept confidential, can you please specify what part or whether all of your response should be kept confidential, and specify why. Please also place such parts in a separate annex.

A1.9 If someone asks us to keep part or all of a response confidential, we will treat this request seriously and will try to respect this. But sometimes we will need to publish all responses, including those that are marked as confidential, in order to meet legal obligations.

A1.10 Please also note that copyright and all other intellectual property in responses will be assumed to be licensed to Ofcom to use. Ofcom's approach on intellectual property rights is explained further on its website at http://www.ofcom.org.uk/about/accoun/disclaimer/

Next steps

A1.11 As set out in section 10, we have made provision in our timetable for a follow-up consultation later this year if required. We expect that we will be in a position to finalise our Statement and draft regulations in early 2009.

A1.12 Please note that you can register to receive free mail Updates alerting you to the publications of relevant Ofcom documents. For more details please see: http://www.ofcom.org.uk/static/subscribe/select_list.htm

Ofcom's consultation processes

A1.13 Ofcom seeks to ensure that responding to a consultation is easy as possible. For more information please see our consultation principles in Annex 2.

A1.14 If you have any comments or suggestions on how Ofcom conducts its consultations, please call our consultation helpdesk on 020 7981 3003 or e-mail us at consult@ofcom.org.uk . We would particularly welcome thoughts on how Ofcom could more effectively seek the views of those groups or individuals, such as small businesses or particular types of residential consumers, who are less likely to give their opinions through a formal consultation.

A1.15 If you would like to discuss these issues or Ofcom's consultation processes more generally you can alternatively contact Vicki Nash, Director Scotland, who is Ofcom's consultation champion:

Vicki Nash
Ofcom
Sutherland House
149 St. Vincent Street
Glasgow G2 5NW

Tel: 0141 229 7401
Fax: 0141 229 7433

Email vicki.nash@ofcom.org.uk

Annex 2

Ofcom's consultation principles

A2.1 Ofcom has published the following seven principles that it will follow for each public written consultation:

Before the consultation

A2.2 Where possible, we will hold informal talks with people and organisations before announcing a big consultation to find out whether we are thinking in the right direction. If we do not have enough time to do this, we will hold an open meeting to explain our proposals shortly after announcing the consultation.

During the consultation

A2.3 We will be clear about who we are consulting, why, on what questions and for how long.

A2.4 We will make the consultation document as short and simple as possible with a summary of no more than two pages. We will try to make it as easy as possible to give us a written response. If the consultation is complicated, we may provide a shortened Plain English Guide for smaller organisations or individuals who would otherwise not be able to spare the time to share their views.

A2.5 We will consult for up to 10 weeks depending on the potential impact of our proposals.

A2.6 A person within Ofcom will be in charge of making sure we follow our own guidelines and reach out to the largest number of people and organisations interested in the outcome of our decisions. Ofcom's 'Consultation Champion' will also be the main person to contact with views on the way we run our consultations.

A2.7 If we are not able to follow one of these principles, we will explain why.

After the consultation

A2.8 We think it is important for everyone interested in an issue to see the views of others during a consultation. We would usually publish all the responses we have received on our website. In our statement, we will give reasons for our decisions and will give an account of how the views of those concerned helped shape those decisions.

Annex 3

Consultation response cover sheet

A3.1 In the interests of transparency and good regulatory practice, we will publish all consultation responses in full on our website, www.ofcom.org.uk.

A3.2 We have produced a coversheet for responses (see below) and would be very grateful if you could send one with your response (this is incorporated into the online web form if you respond in this way). This will speed up our processing of responses, and help to maintain confidentiality where appropriate.

A3.3 The quality of consultation can be enhanced by publishing responses before the consultation period closes. In particular, this can help those individuals and organisations with limited resources or familiarity with the issues to respond in a more informed way. Therefore Ofcom would encourage respondents to complete their coversheet in a way that allows Ofcom to publish their responses upon receipt, rather than waiting until the consultation period has ended.

A3.4 We strongly prefer to receive responses via the online web form which incorporates the coversheet. If you are responding via email, post or fax you can download an electronic copy of this coversheet in Word or RTF format from the 'Consultations' section of our website at www.ofcom.org.uk/consult/.

A3.5 Please put any parts of your response you consider should be kept confidential in a separate annex to your response and include your reasons why this part of your response should not be published. This can include information such as your personal background and experience. If you want your name, address, other contact details, or job title to remain confidential, please provide them in your cover sheet only, so that we don't have to edit your response.

Cover sheet for response to an Ofcom consultation

BASIC DETAILS

Consultation title:

To (Ofcom contact):

Name of respondent:

Representing (self or organisation/s):

Address (if not received by email):

CONFIDENTIALITY

Please tick below what part of your response you consider is confidential, giving your reasons why

Nothing ☐

Whole response ☐

Part of the response ☐

Name/contact details/job title ☐

Organisation ☐

If there is no separate annex, which parts?

If you want part of your response, your name or your organisation not to be published, can Ofcom still publish a reference to the contents of your response (including, for any confidential parts, a general summary that does not disclose the specific information or enable you to be identified)?

DECLARATION

I confirm that the correspondence supplied with this cover sheet is a formal consultation response that Ofcom can publish. However, in supplying this response, I understand that Ofcom may need to publish all responses, including those which are marked as confidential, in order to meet legal obligations. If I have sent my response by email, Ofcom can disregard any standard e-mail text about not disclosing email contents and attachments.

Ofcom seeks to publish responses on receipt. If your response is non-confidential (in whole or in part), and you would prefer us to publish your response only once the consultation has ended, please tick here. ☐

Name

Signed (if hard copy)

Annex 4

Consultation questions

Sub heading

A4.1 This annex provides a list of the questions included in this consultation document.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Question 42: Do you agree with our assessment that the limitations on the amount of cleared spectrum available for mobile broadband applications, and the particular advantages of sub 1GHz spectrum, could result in an outcome where there are limits on the level of competition possible in the provision of these services?

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

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

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

Annex 5

Impact assessment

Introduction

A5.1 The analysis presented in this annex represents an impact assessment, as defined in section 7 of the Communications Act 2003 (the Act).

A5.2 You should send any comments on this impact assessment to us by the closing date for this consultation. We will consider all comments before deciding whether to implement our proposals.

A5.3 Impact assessments provide a valuable way of assessing different options for regulation and showing why the preferred option was chosen. They form part of best practice policy-making. This is reflected in Section 7 of the Act, which means that generally we have to carry out impact assessments where our proposals would be likely to have a significant effect on businesses or the general public, or when there is a major change in 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

A5.4 We have already consulted on our approach to the award of the spectrum freed up by digital switchover for new uses. Our analysis of the policy options relating to the general approach has been set out in two previous impact assessments, the first as part of our December 2006 Consultation and the second updated version as part of our December 2007 Statement. These assessments included consideration of the approach to the award of both cleared and interleaved spectrum as well as spectrum which was not cleared as a direct consequence of DSO and which is currently used for other services (i.e. channels 36 and 69).

A5.5 The analysis of options undertaken in this first phase of work, and as summarised in the two previous impact assessments, led us to conclude that for the DDR cleared award a market led approach was more likely to meet our objective for the DDR than the alternative, interventionist approach. We decided not to intervene to reserve cleared spectrum for any particular use. Instead, we decided to award this spectrum via a service- and technology-neutral auction.

A5.6 Having established the approach we will take to the DDR cleared award, we now consider the method by which we will award the spectrum. This consultation focuses on the method and process for the auction of cleared spectrum in channels 31 to 40 and channels 63 to 68 (and the interleaved spectrum in channels 61 and 62).

A5.7 Two further consultations on the DDR, due to be published shortly, will focus on the method and process for the award of interleaved spectrum. These are as follows:

- A consultation on our proposals to auction interleaved geographic packages suitable but not reserved for local television; and

- A consultation on our proposals to award a single package of interleaved spectrum to a band manager with obligations toward the PMSE sector.

The citizen and/or consumer interest

A5.8 Our primary duties are to further the interests of citizens in relation to communications matters and to further the interest of consumers, where appropriate, by promoting competition. In the first phase of the DDR, the potential benefits to citizens and consumers were the focal point of our analysis. When deciding between the competing policy options for our approach to the award, we were guided by the total value each one of them could generate for society over time, including the benefits for consumers, for producers and for citizens.

A5.9 In this, the second, phase of the DDR, we can further improve the outcome of this award of spectrum for citizens and consumers by careful design of the spectrum packages, detailed auction format and rules and the licence terms and conditions. This will involve balancing some key trade-offs. For example, the technical licence conditions must protect existing users of the spectrum, and by extension, the citizens and consumers who use these services, while at the same time maximising its usability and hence value for new uses. Also, the spectrum packages should be flexible enough to accommodate the different potential uses, thereby promoting competition and innovation and resulting in more choice, new services and better prices for consumers, while at the same time reflecting the specific constraints that apply to the spectrum.

Our policy objective

A5.10 Our overarching objective in releasing the digital dividend is to maximise the total value to society generated by the use of this spectrum over time.

Options considered

A5.11 There are several ways that we can achieve this objective in our design of this award. We can:

- choose appropriate technical licence conditions (TLCs) that consider the need to protect existing users of spectrum while maximising flexibility for new uses;
- choose appropriate non-technical usage rights which provide certainty of tenure and help to promote efficient outcomes;
- design spectrum packages which best reflect the demand for the spectrum and the specific technical constraints on the spectrum;
- design an efficient auction process that promotes competition and encourages bidders to express their true value for the spectrum; and
- consider whether further remedies may be required to ensure that competition and efficiency are promoted through the award and use of the spectrum.

A5.12 For each of these areas, we have considered a range of options and our full analysis of these options is set out in the main body of this consultation document. In the remaining part of this impact assessment, we summarise our analysis in respect of some of the key issues for the DDR cleared award and cross reference this to the relevant sections in the main body of the document.

Analysis of the different options

Choice of technical licence conditions

Type of condition

A5.13 One of the key issues for this award is the type of technical licence condition that should be included in the licences of available spectrum. We have considered two main options:

- Transmit masks
- Spectrum Usage Rights (SURs)

A5.14 Table A5.1 sets out a summary of our analysis of the advantages and disadvantages associated with each type of TLC. (We consider this issue in more detail in paragraphs 5.1 - 5.13 of section 5):

Table A5.1: Transmit masks or SURs

Options	Advantages	Disadvantages
Transmit mask	Tried and tested Simple to understand Relatively easy to assess compliance Allows for a level of flexibility to deploy different types of service	Restricts ability to optimise power/density trade-off in transmission networks Difficult to estimate the expected interference levels from neighbouring licensees Wide range of possible uses in cleared spectrum make this a particular problem
SUR	Provides a higher level of interference protection and certainty to neighbours than mask-based licences Allows flexibility to deploy different types of service Especially suitable for spectrum where there is wide range of possible uses	More complex to define and compliance assessment is not as straightforward as for mask-based licences

A5.15 In the case of DDR cleared spectrum, we believe that the potential for a wide range of uses tilts the balance in favour of SURs and propose that technical licence conditions should be presented in this form.

Choice of protection method for existing DTT services

A5.16 There is a risk that new services deployed in cleared spectrum could cause harmful interference to existing DTT services in adjacent spectrum and prevent the reception of DTT signals. Providers of DTT services plan their coverage to reach a high percentage of the UK population, and in the case of PSB DTT providers are obligated to do so. In view of this, we consider that it is appropriate to consider how to provide a high level of protection for users of existing DTT services.

A5.17 We have considered various methods which could potentially be used in addition to standard TLCs in order to protect existing DTT services. In deciding on the most appropriate option, we have needed to strike the right balance between managing the risk of interference and unnecessarily sterilising spectrum. If the balance tends too much toward eliminating the risk of interference, this may limit the value of spectrum for new uses. Some of the methods we have considered are covered below:

a) Guard bands and/or extra emission restrictions

- While these could in theory offer the required level of protection, the restrictions required would in practice have to cover a large number of frequencies and an equally large geographic area. This approach would therefore not be spectrally efficient as it would significantly reduce the amount of usable spectrum that could be awarded in the DDR cleared award. Furthermore, even very wide guard bands may not deal with the potential problem of interference via the “n+9” image channel, where services further away in frequency from the existing broadcast network may still cause interference. (However, in the specific case of protecting existing DTT services from mobile transmissions, we note that a guard band will be necessary).

b) Geographic exclusion zones

- It is difficult for us as a regulator to determine the appropriate exclusion zones in the absence of the detailed knowledge of the networks which will be deployed. Therefore we are likely to have to make conservative assumptions resulting in larger exclusion zones than may be required in practice. Whilst we believe this approach may be effective in safeguarding the existing DTT network from interference we do not believe it is the most effective means by which we can balance this with our duty to ensure optimal use of the spectrum.

c) Protection clause

- This clause would give new licensees flexibility to decide on the most efficient way to deploy their particular network, thereby maximising the utilisation of the radio-spectrum close to DTT in frequency and geographic terms where appropriate, while still ensuring protection to existing DTT services.

A5.18 We propose that the addition of a protection clause to licences in the cleared spectrum is the most effective means of ensuring DTT reception is maintained in the UK and that optimal use of the radio spectrum is made. We provide fuller details on this issue in 5.62 – 5.95 of section 5 and in Annex 6.

Non-technical usage rights - interoperability

A5.19 Existing DTT multiplex operators are required to adopt certain technical standards and operating parameters. This means that viewers benefit from receiving a common service across all six existing DTT multiplexes. Given the possibility that cleared spectrum will be used to deliver new DTT services, we have considered the issue of interoperability with the existing multiplexes and the extent to which regulatory intervention may be needed to secure this. We have identified and analysed three options as set out in Table A5.2 below:

Table A5.2: Interoperability options

Options	Advantages	Disadvantages
Do nothing	Potentially consistent with our duty to regulate only where necessary if no need for interoperability Likely to be benefits (and therefore incentives) for all multiplex operators in interoperating voluntarily to maximise viewer benefits	Not guaranteed to deliver interoperability Our ability to intervene subsequently in favour of interoperability would be limited
Facilitate	Preserves our preference for operators to come to interoperability agreements voluntarily Gives us the ability to intervene decisively if circumstances frustrate such agreements	Does not guarantee viewers the benefits of interoperability across all multiplexes at the earliest possible time
Mandate	Guarantees viewers the benefits of interoperability across all multiplexes	Automatically precludes alternative market offerings that could deliver different, possibly greater benefits to viewers In the absence of a compelling reason to intervene in this way, sits ill with our duty to regulate only where necessary

A5.20 We propose to facilitate interoperability between existing and new multiplex operators at the request of the latter. We consider this option to be the most proportionate response to address the issue as we perceive it.

Spectrum packaging

A5.21 The spectrum packages offered in the DDR cleared award need to reflect the specific technical constraints that apply to the spectrum available for award (as set out in section 5) as well as certain non-technical conditions (set out in section 6).

A5.22 Having taken these into account, a number of key choices remain in determining the packages to be included in the DDR cleared award:

- Frequency size of lots;
- Specificity of lots;
- Packaging rules; and
- Geographic scope of lots.

A5.23 Our analysis of the case for imposing certain packaging rules is set out in paragraphs 7.89 – 7.103 of section 7 and is not repeated here. Tables A5.3, A5.4 and A5.5 set out a summary of our analysis in relation to the three other key spectrum packaging issues:

Table A5.3: Frequency size of lots

Options	Advantages	Disadvantages
1 MHz lots	Maximum flexibility - lots could be aggregated by bidders to form a package of spectrum to cover any technology that is likely to be used and provides flexibility for potential future technologies	Would require a very complex auction Increases the risks of interference, by multiplying the number of potential boundaries between licensees
5 MHz lots	Current two way communication technologies use 5 MHz channel bandwidths (or a multiple thereof)	Could favour some services over others, potentially biasing auction outcomes Could result in wasted spectrum if used for other services, e.g. DTT
8 MHz lots	Fits neatly within existing broadcast channel plan and would be suitable for DTT and MMS technologies	Could favour some services over others, potentially biasing auction outcomes Could result in wasted spectrum if used for other services, e.g. two way communications
8 MHz lots in lower sub-band, 5 MHz lots in upper sub-band	Stakeholder research and European developments indicate that two way mobile communications are a likely use	Would require us to prejudge auction outcomes (e.g. only broadcasting in the lower sub-band), risking regulatory failure

	of the upper sub-band Covers the likely services which we believe could be deployed in the cleared spectrum	
Both 5 and 8 MHz lots in all of the available spectrum	Covers the likely services which we believe could be deployed in the cleared spectrum and minimises the chance that bidders need to buy more spectrum than they require to provide the services they wish to deploy, resulting in a better chance of spectrum efficient outcomes	More complex auction design
Larger packages (e.g. lower and upper sub-bands as individual lots)	Would simplify the auction design and process Minimises the risks of interference, by minimising the number of potential boundaries between licensees	We covered this option in our December 2006 DDR consultation. This option has the potential to restrict the development of competition and variety of applications requiring less spectrum

A5.24 We propose to offer both 5 and 8 MHz lot sizes in the auction. The reasons for this are discussed in more detail in paragraphs 7.15-7.23 of section 7.

Table A5.4: Specificity of lots

Options	**Advantages**	**Disadvantages**
Generic lots	Results in a simpler auction for bidders A more flexible auction is facilitated so that a greater variety of bidder requirements can be simultaneously accommodated Limits risks of strategic bidding by bidders Lower chance of unsold lots	The cleared spectrum is subject to some very material sources of value variation by frequency due to existing services and their use of adjacent channels. This consequently has the potential to influence the value placed on auction lots by bidders If significant value differences are ignored in packaging, can result in exposure risks and can reduce the competitiveness of the auction
Specific lots	Would more completely reflect the material value differences between frequencies in cleared spectrum award	Potentially results in a very complex auction with associated risks of efficiency losses

Hybrid approach	Allows us to take into account of the most material likely value differences between frequencies while still creating some generic lot categories and maximising the chances of achieving an efficient auction design	Potentially results in a complex auction but not to the same extent as would be the case if all lots were specific

A5.25 We propose to adopt the hybrid approach to lot specificity, thereby providing a mixture of frequency-specific and frequency-generic lots in the auction. The reasons for this are discussed in more detail in paragraphs 7.24-7.88 of section 7.

Table A5.5: Geographic scope of lots

Options	Advantages	Disadvantages
UK-wide lots	More spectrally efficient to allocate spectrum across the UK as a whole rather than at a smaller level Results in a simpler auction design, increasing the likelihood of an efficient outcome and minimising the possibility of unsold lots Reflects preferences for UK wide licences as stated by most stakeholders	Use of certain channels by certain services (particularly high power, high tower services) in Northern Ireland may be limited by interference from Republic of Ireland
Sub-UK lots	Would allow us to satisfy demands from some stakeholders for spectrum on a sub-UK basis	More spectrally efficient to allocate spectrum across the UK as a whole rather than at a smaller level Difficult for the regulator to determine the appropriate geographic areas for sub-UK licences Geographic segmentation may also increase the likelihood of unassigned licences which would not promote efficient use of the spectrum
Separate NI lots (coordinated award of NI lots with Republic of Ireland)	If the same bidder were to win corresponding spectrum in Republic of Ireland and Northern Ireland, and subsequently rolled out an all-	This option would make it difficult for bidders interested in providing UK-wide services to secure the spectrum they would need to roll-out UK-wide

	Ireland service, this would maximise spectrum efficiency and minimise wasted spectrum at the land border Would satisfy requests of some stakeholders in Northern Ireland for separate award of spectrum	services - our stakeholder research shows that most bidders are interested in UK-wide lots The Republic of Ireland has not finalised its digital switchover plans. And there is no guarantee that any digital dividend that it may identify would correspond to the cleared spectrum in the UK
Flexibility for auction to decide (between UK wide lots and separate Great Britain/NI lots)	Would allow the market to make the trade-off between the potential advantages of early access to UK-wide spectrum and the advantages of acquiring Northern Ireland spectrum in anticipation of aggregating it with Republic of Ireland spectrum at a later date	Proposed auction design for DDR cleared award is already relatively complex - adding a further level of complexity could increase the risks of inefficient auction outcomes and may even be impractical to design

A5.26 Therefore we propose to offer UK-wide lots. The reasons for this are discussed in more detail in paragraphs 7.104-7.127 of section 7.

A5.27 In summary, the above analysis leads us to propose that the spectrum packages for the DDR cleared award should have the following design features:

- We propose to offer both 5 and 8 MHz lot sizes in the auction;
- We propose to adopt the hybrid approach to lot specificity, thereby providing a mixture of frequency-specific and frequency-generic lots in the auction; and
- We propose to offer UK-wide lots.

Auction Design

A5.28 When choosing an appropriate auction design, there are several key design choices to make as set out below:

- Single round (sealed bids) or multiple rounds (ascending bids);
- Simultaneous or sequential award of lots;
- Package bids or multiple bids for individual lots; and
- Generic or specific lots

A5.29 Table A5.6 below sets out our analysis of the advantages and disadvantages relating to each of these options with specific reference to the DDR cleared award. (For generic and specific lots, we note that the analysis set out in the previous subsection on spectrum packaging applies equally to the auction design choice

between these two options and is therefore not repeated here). More detail on the key auction design choices is provided in paragraphs 8.14 – 8.37 of section 8.

Table A5.6: Key auction design choices

Options	Advantages	Disadvantages
Single Round	Simple to administer Where there are significant bidder asymmetries and related concerns about the level of competition in the auction, a single round sealed bid process can encourage participation	This option does not facilitate price discovery and therefore bids are less likely to reflect true value – therefore highest value user may not win. May also result in "winner's curse" - when a bidder over-values an asset due to having incomplete information
Multiple Round	For the DDR cleared award, there is likely to be significant uncertainty over the evolution of demand for many of the potential uses of this spectrum. Also, some bidders will be targeting very similar downstream markets and will have a high degree of common value uncertainty. Bidders may benefit greatly from being able to observe how their competitors shift demand in response to prices. Furthermore, prices are likely to better reflect true valuations In the case of cleared spectrum, there is uncertainty as to the relative amounts of spectrum that should optimally be assigned to each of the competing technical licence types. A multiple round process will enable the competing demand for technical licence types to dynamically achieve an efficient outcome A multiple round process allows bidders to switch their demand to different lots in response to changes in relative prices, thereby enabling them to avoid substitution risks	Potential to become complicated depending on other aspects of auction design
Simultaneous	In the cleared spectrum, multiple lots would potentially	Threshold risks are higher

	be close substitutes and complements for the different services that could make use of the band – a simultaneous approach is most appropriate in this case	
Sequential	Fosters a degree of market testing Threshold risks are lower	High aggregation risk High level of uncertainty around future outcomes
Package (or combinatorial) bidding	Reduces exposure/aggregation risk More suitable for complementary lots	More complex auction Higher threshold risks – risk that smaller bidders, who for example might want only individual lots, may be unable to adequately coordinate their demand to displace such larger bidders – but other aspects of auction design can be used to mitigate this risk
Multiple bids for individual lots (i.e. no package bidding)	Less complicated auction Helps smaller bidders who want limited number of lots	High exposure/aggregation risk: – bidders must bid separately for one lot without certainty over whether, and at what price, they might win the complementary lots; – bidder risks winning only a subset of the lots it requires, which would be inefficient; – such risk tends to encourage conservative bidding, which may mean that bidders fail to win the appropriate number of lots even though they may have the highest valuation on those lots

A5.30 The above analysis leads us to propose that the award of the cleared spectrum should have the following design features:

- a simultaneous award process;
- multiple round bidding;
- generic lots where possible; and
- combinatorial bidding (alternatively referred to as package bidding).

A5.31 These choices narrow down the choice of auction format. There are three variants of an SMRA format which could potentially be employed based on the above choices:

- Standard SMRA (with ability to switch between rounds);
- SMRA with package bidding; and
- Combinatorial Clock format.

A5.32 We set our analysis of these three variants in Table 5.7 below. These issues are discussed in more detail in section 8:

Table A5.7: Choice of auction format

Options	Advantages	Disadvantages
Standard SMRA (with ability to switch demand between rounds)	Proven auction format used for auctions of 3G and FWA licences worldwide Allows bidders to express their relative preferences between lots based on relative prices Avoids the need for any follow-up process to assign actual lots to bidders Low threshold risk	Exposure/aggregation risks - bidders risk winning non-contiguous spectrum or only a subset of desired lots and may bid conservatively – this risk may be reduced (but not eliminated) by using augmented switching rules
SMRA with package bidding	Allows bidders to eliminate aggregation risks by specifying all permutations of lots they might need in every round	Imposes a large burden on bidders to evaluate all such bids where there are many permutations available Higher threshold risks than standard SMRA
Combinatorial Clock Auction (CCA)	No aggregation risk for bidders and no risk of being stranded with unwanted lots Simpler for bidders than SMRA with package bidding Has been successfully employed in the recently completed 10-40 GHz award and the L-Band award	Higher threshold risks than standard SMRA

A5.33 We consider that a simultaneous multiple-round combinatorial clock auction (CCA) is the most suitable auction design as it can incorporate all the necessary elements

required to ensure an efficient allocation process whilst at the same time providing a simple and intuitive interface for bidders to use during bidding.

A5.34 Although the CCA design is relatively new in comparison to the standard SMRA, it has been successfully employed by Ofcom in the recently completed 10 GHz, 28 GHz, 32 GHz and 40 GHz award and the 1452-1492 MHz award. It has also been proposed as the preferred format for the upcoming 2500-2690 MHz, 2010-2025 MHz and 2290-2300 MHz ("the 2.6 GHz") award.

Promoting competition and efficiency

A5.35 We have considered how the award of cleared spectrum can best promote competition and efficiency in downstream markets. Beyond taking into account the need to promote competition and efficiency through auction design and packaging, we have considered:

- the need for general provisions and safeguards to provide spectrum holders with sharper incentives to use spectrum efficiently and to promote competition. These safeguards would if adopted apply to all spectrum holders irrespective of the use to which they put the spectrum; and
- the risks of specific award outcomes resulting in a less competitive market structure than would otherwise be possible and identifying whether targeting intervention to prevent or resolve these particular outcomes would be an appropriate regulatory response to such risks.

A5.36 Key conditions for considering whether or not to adopt any remedies will be that:

- the remedy can be expected to be effective; and
- the cost of any remedy in terms of regulatory failure or unintended consequences is expected to be significantly outweighed by the significance and likelihood of the competition or efficiency issue.

A5.37 Table A5.8 sets out our consideration of options under general provisions.

Table A5.8: Options for general provisions

Option	Advantages	Disadvantages
Use it or lose it requirements	Effective and beneficial where it is clear that a significant risk exists that spectrum will be held idle and that such idle holding is inefficient	Difficult in practice to define and detect where spectrum is held idle May have unintended consequences where spectrum use is forced in circumstances where it is not efficient to do so Could act as significant barrier to efficient trading
Rollout obligations	Directly increases chances that spectrum is utilised and citizens receive benefits where rollout is	Implies additional costs on spectrum holders and so may distort primary or secondary

	not commercially attractive	purchase of spectrum Other solutions are available to achieve same outcome more efficiently; e.g. direct funding
Information provisions	Publicly available information regarding spectrum ownership and use facilitates value formation, price discovery and hence efficient spectrum trading Likely to be effective in a range of circumstances and market outcomes	Need to recognise appropriately any commercial confidentiality concerns that the public release of the data might raise
Access requirements	Can be effective in promoting downstream competition in face of upstream scarcity of spectrum, particularly where nature of service and required access is clear	Access conditions can be complex to specify and difficult to implement; inappropriate terms could either unduly favour or penalise access provider and have unintended consequences and costs For cleared spectrum, not clear what the nature of services to be provided through cleared spectrum is, hence difficult to specify any general access conditions which apply to all potential uses
Spectrum caps	Relatively straightforward to understand and implement Can be effective structural solution, by reducing opportunities for less competitive market structures to emerge following award Can be used in general or specific manner	Requires careful judgement about level in order to minimise risks of unintended consequences

A5.38 We discuss our approach to general provisions and options in paragraphs 9.31 to 9.63 of section 9.

A5.39 Overall we conclude that two general interventions may be appropriate: a 50 MHz safeguard cap on the allowed purchase of cleared spectrum by an individual bidder, and an information provision clause that will help facilitate an efficient secondary market.

A5.40 Regarding the risk of specific market failures, we have identified that there is a risk that any Next Generation Mobile (NGM) networks deployed using frequency such as that available in the cleared spectrum may have a competitive advantage over networks which may be deployed using only other, significantly higher frequencies. We considered two potential options for addressing the risk; some form of spectrum cap, or some form of access condition. We particularly suggested that some form of enduring 'soft' cap which, if exceeded, would trigger particular licence conditions such as the reservation of our right to take back the spectrum in excess of the cap throughout the licence term, would be an appropriate option. We also noted that the level of the cap might be set either with reference to the cleared spectrum alone or with reference to holdings of spectrum in the sub 1 GHz band.

A5.41 Table A5.9 sets out our consideration of the options for addressing this risk.

Table A5.9: Options in respect of the specific market failure risk identified – Sub 1 GHz spectrum for mobile broadband

Option	Advantages	Disadvantages
Impose no restrictions	Bidders can express their demand for every quantity of spectrum that they require, so promoting an efficient outcome	Risk of establishment of market structure in respect of NGM services not conducive to promotion of competition or to interests of citizens and consumers
Soft spectrum cap set with reference to cleared spectrum	Guards against a low risk, but adverse, scenario where one participant acquires all (or most) of the spectrum and this limits opportunities for others to enter Likely to be effective because it promotes competition through diversity of holdings at time of award and subsequently The 'soft' nature of cap would not overly constrain spectrum ownership but nevertheless affords more flexible approach regarding potential competition concerns	We would need to be careful in setting the level of the cap. There are: - Risks of setting level of cap too low and so tending to eliminate or reduce possibilities for efficient scale size and hence spectrum use - Risks of setting cap too high and so tending to limit effective competition
Soft spectrum cap set with reference to sub 1 GHz spectrum	As for spectrum cap set with reference to cleared spectrum Likely to capture nature of competition concern better, since sub 1 GHz spectrum may be substitutable in terms of providing NGM networks in	As for spectrum cap set with reference to cleared spectrum

	the future	
Access requirements	In some situations can foster downstream competition even where there are upstream bottlenecks on key spectrum input	Terms of access need to be carefully determined Requires on-going regulatory oversight. May be subject to a degree of regulatory failure

A5.42 We discuss the issue of sub 1 GHz spectrum for mobile broadband and associated competition issues and potential approaches and options in paragraphs 9.75 to 9.92 of section 9.

A5.43 We conclude that some form of 'soft' enduring spectrum cap is likely to be the most effective form of remedy to competition concerns in respect of mobile broadband and NGM networks.

Annex 6

Practical implementation of licence conditions

Introduction

A6.1 In section 5, we described our proposals for addressing the potential for interference to DTT receivers caused by new services operating in the cleared spectrum. In summary, our preferred approach is to include in the licences granted to successful bidders within the cleared spectrum an obligation which:

- requires licensees in bands adjacent to DTT bands to plan their network so as to avoid any interference with DTT receivers based on the detailed coverage/transmission plan of the post DSO DTT network;
- requires licensees to remedy any interference should it occur. How this is done will be for the licensee to determine. They could meet this requirement by moving the interfering transmitter, by arranging the installation of a filter for receiving equipment or where these or any other prevention measures cannot or are not likely to prevent interference, to pay the viewer the costs of obtaining an alternative digital television service.

A6.2 This annex is structured as follows:

- We start by setting out how interference with television and radio signals is dealt with today;
- We then set out a proposed approach to the protection clause by way of a straw man proposal;
- We describe some of the practical issues underpinning the proposed protection clause and highlight our current thinking as a basis for industry consideration.

A6.3 We believe that the most effective way of progressing our current thinking on the protection clause and on implementing the clause is through engagement with stakeholder groups.

Dealing with interference to television and radio signals

Planning at network level

A6.4 As we described in section 5, interference between different uses is managed by imposing a set of technical licence conditions on licensees that have the effect of limiting the amount of interference that is caused. Licensees can coordinate between themselves to address interference concerns, within the scope of the technical requirements of their licences.

A6.5 A specific example of co-ordination is the Joint Planning Project for the Further Development of Digital Television Frequency Planning (the “JPP”). The JPP was established by a Memorandum of Understanding (“MoU”) between the original members who work together to plan the use of the frequencies used by broadcast

television in the UK to facilitate the introduction of digital terrestrial television. The members of the JPP are: Ofcom, the BBC, Arqiva, National Grid Wireless, Digital 3&4, SDN, Channel 4, ITV and S4C.

A6.6 Joint planning is effected based on the UK Planning Model, which is in fact a composite of three separately developed and run models owned by each of the BBC, Arqiva and NGW. The JPP is concerned with the planning of broadcast frequency channels in the UHF band. It does not plan or coordinate for other channels.

A6.7 Licensees can rely upon the planning papers agreed through the JPP when planning their networks to ensure that their equipment is installed in such a way as to not cause interference to other services.

A6.8 The implementation of digital switchover (DSO) is expected to cause an increase in the levels of interference to some existing analogue and DTT viewers as the necessary changes are being rolled out on a region by region basis. This can mean that the adoption of the final post DSO frequencies and powers in one region can result in an increase in interference to existing viewers in a neighbouring region.

A6.9 We have put in place a Code of Practice on Changes to existing Transmission and Reception Arrangements. The DTT multiplex operators are required to adhere to this Code through their licences. This Code requires that they minimise the levels and extent of interference to existing viewers through a variety of mitigation and planning techniques and that they gain our approval for measures when the predicted impact of the interference is high and the viewers affected have no alternative means of viewing the terrestrial service.

Investigation of complaints

A6.10 Where we receive a complaint from a resident about interference and the complaint meets the relevant criteria[70], we will carry out an investigation. A trained and authorised field engineer will contact the resident and arrange a site visit. During this visit the engineer will use specific equipment to locate the source of interference. The engineer will also determine whether the interference is caused by an external source and confirm that the resident's equipment conforms to all relevant legislation, is engineered to meet the relevant technical standards and is correctly licensed. Should the engineer find fault with an aspect of the resident's installation, we will make a charge for any remedy.

A6.11 Our investigation may involve a request to the BBC, NGW and Arqiva for access to the UKPM. To date, Ofcom has not incurred a charge for this but this will change in the future.

A6.12 We are also able to use suitably authorised external personnel to investigate interference complaints and this is recognised in standard technical licence conditions included in WT Act licences. Ofcom or a person authorised by Ofcom can require a licensee to modify or restrict the use of equipment, or switch off that

[70] For example for domestic TV and radio reception, Ofcom cannot investigate cases of interference if households do not have a rooftop aerial (as set-top aerials are much less effective than a properly-fitted rooftop aerial) or if the householder lives in a building with a shared aerial system (for example, a block of flats) in which case the landlord should contact us.

equipment, where Ofcom or the authorised person considers that the licence has been breached or where:

> the use of the Radio Equipment [the apparatus described in the Schedule to a licence] is causing or contributing to interference to the use of other authorised radio equipment.[71]

A6.13 We can require that equipment be temporarily or permanently switched off. Failure to modify or restrict the use of faulty or interfering equipment or to shutdown that equipment would be a breach of the licence conditions.

A6.14 We can enforce a breach of licence conditions by serving a notice on the licensee under Section 39 of the WT Act. Failure to comply with the notice may lead to prosecution.

Investigating interference to domestic TV reception

A6.15 Residents who experience interference with their domestic TV or radio reception can contact Ofcom to register a complaint. The Ofcom website sets out the process for doing so[72]. We will investigate and attempt to resolve or remove sources of interference, but we charge the complainant if we find that faults in, or problems with, the TV, radio or other electrical equipment within their home (such as thermostats) have caused the reception problem. Information is provided on our website to guide complainants to contact their dealer or reputable aerial installer where this might be the case.

A6.16 If we consider that it is appropriate to investigate, an Ofcom representative will visit the resident's premises during working hours to assess the problem. The investigation will try to identify the cause of the interference and, if possible, resolve it.

- If the interference is caused by an outside source (such as illegal radio transmissions or faulty electrical apparatus), we will take appropriate action and will not charge the resident.
- If the interference is caused by problems with the broadcast signal itself (see below), we will provide a report on what is wrong but will not be able to resolve the interference. Again, we do not charge the resident.
- If the interference is caused by the householder's own installation (for example, a faulty aerial, receiver, cable or plugs) or by any part of the viewer's domestic electrical system, we will charge a fee of £50 (GBP) including VAT. (There is no charge if the household is covered by a free TV licence.)

A6.17 Although we do not repair faulty or poorly-installed equipment, in some cases we can fit a filter which may reduce interference problems. If we fit more than one filter, we may make an extra charge. Following our investigation a written report containing our recommendations is provided for the resident.

A6.18 Residents must have a satisfactory aerial for their TV or FM radio. We do not investigate problems if the resident uses a set-top aerial or an aerial built into the set.

[71] Paragraph 14, standard technical licence conditions, see also Annex 9.
[72] http://www.ofcom.org.uk/radiocomms/ifi/glines/interference/interference/

A6.19 Our service is not available to residents if they live in a hotel, a block of flats or a housing estate with a shared aerial system. Here, we suggest that the resident contact the landlord, owner or nominated contractor, who can contact us for an investigation if they wish.

A6.20 The interference service relates primarily to analogue television and radio. However, we note that DTT reception problems can happen in areas that have weak signals. Here, we suggest that callers consult their dealer if they have difficulties with reception in the first instance, but we will ultimately investigate if there is interference to the service.

A6.21 Our television and radio interference work is undertaken under an agreement with the BBC. The BBC is required to "make reasonable arrangements for the investigation, at the BBC's expense, of complaints of interference by electro-magnetic energy affecting domestic television and radio reception within the UK."[73] An earlier form of this obligation had been implemented by the BBC contracting the Radiocommunications Agency to provide the front-line investigation service. The service provided by the Radiocommunications Agency – which has transferred over to Ofcom – covered interference to television and radio services. Some types of interference are excluded, e.g. to Five.

A strawman protection clause

A6.22 One of the aims of the protection clause is to place the costs of interference management and resolution as far as possible in the hands of the licensee causing the interference. We believe that this reflects an appropriate balance of our duties, in particular to ensure optimal use of the spectrum and taking into account the different uses and users involved with spectrum.

A6.23 As described in section 5, we propose that new licensees will be required to plan their networks so as to prevent any interference being experienced by DTT viewers through their roof top aerials so that signals received within a defined reception area are not interfered with. We consider below what information should be made available to licensees to enable them to meet this obligation.

A6.24 We recognise that licensees will not be able to plan in such a way that they can guarantee that interference will not occur at all. We consider that the obligation should therefore require them to plan so that, as far as is possible, no interference to roof top aerial reception within the relevant area will be experienced.

A6.25 One possible approach to this planning obligation could be to draw upon the Code of Practice developed for changes to DTT transmission described in paragraph A6.9 and provide for a similar mechanism within the protection clause. Such a Code (or other mechanism) could set out in more detail what is expected of licensees in terms of planning. For example, there may be cases where our guidance is needed on whether a particular installation approach is likely to cause interference or where the planning information available may not itself provide an answer as to whether interference is likely. It is also worth considering whether a more formal role for us would be appropriate, e.g. to approve a particular network plan

A6.26 We consider that the licensee should also be required to address any interference caused by its transmissions. We do not consider that we are best placed to

[73] Paragraph 82 of the Agreement between Her Majesty's Secretary of State for Culture, Media and Sport and the BBC (approved in Parliament in July 2006) sets out the current form of the obligation.

determine in advance how the licensee should do this. As a result, we propose that while the licensee will be required to correct any interference it is causing, the protection clause will not specify how this must be done. The protection clause will make it clear that the licensee, if it cannot resolve the matter, must pay the viewer an amount of money enabling the viewer to take up an alternative digital service. This can include both cable or satellite services.

A6.27 We acknowledge that this is not the only possible approach for a "protection clause". We include the approach set out in this Consultation Document as a straw man proposal to form the basis of discussions with stakeholders. This proposal, and other possible variations, will have an impact on our current investigations process and resourcing. We will therefore also need to consider this impact as the proposals are developed with stakeholders and share the outcome of this consideration with stakeholders.

Practical implications of the proposed approach

Access to planning and other relevant information

A6.28 In order to meet the obligation to plan their network in a manner that prevents interference to DTT receivers, the licensee will need to know where the DTT transmitters are located, their physical and technical characteristics, e.g. height, power output, their coverage areas, the restrictions or coordination requirements that may apply and the geographic characteristics of an area.

A6.29 Some of this information is publicly available; for example, we publish a list of broadcast television transmitters, their locations, frequencies and powers. Information on DTT coverage at discrete locations is available through the Digital UK website via their postcode checker.

A6.30 However, the output of the UKPM is not currently made available publicly. The use of the UKPM or a copy of its output (based upon the UK DTT plan) would be necessary to enable licensees in adjacent channels to meet the proposed obligation to plan their networks as far as possible to avoid interference with DTT receivers.

A6.31 The JPP has developed a transmission plan for the UK's six DTT multiplexes. This plan aims to ensure that the post-switchover coverage of the three multiplexes carrying the public service channels achieves a coverage at least as extensive as analogue television (estimated to be 98.5% of households). We propose that new licensees will be required to plan against this transmission plan and coverage objectives and consider that the most suitable aggregated information for planning purposes is contained in the output of the UKPM. However, this output, while made available to us for investigation purposes, is not made available for the purposes of licensing.

A6.32 One option to explore is whether the membership of the JPP could be expanded to include new licensees, who could then participate in the planning process and have access to the UKPM on appropriate terms. In the post-DSO world, it is also not clear if the UKPM will be developed further by JPP given that its purpose is to assist with achievement of the 98.5% coverage requirement and the planning of the commercial multiplex assignments at the 80 sites they currently operate from. Depending on the life of the protection clause (which is considered in section 5), this may make it increasingly difficult for licensees to rely upon the output of the UKPM for the purposes of network planning.

A6.33 Alternatively, it may be sufficient to rely upon coordination between licensees, including DTT multiplex licensees, in order to ensure that the new licensees obtain the information they need in order to plan their networks in accordance with the protection clause. There are likely to be other models for ensuring access to the necessary information, which we would like to explore with stakeholders.

A6.34 We are also aware that the members of JPP could be involved in planning new networks on a commercial basis. In addition, Arqiva/NGW may be asked by Ofcom to run the UKPM as part of an investigation into interference. This raises the possibility of conflicts of interest arising between the different roles played by each company. We would like to explore with stakeholders whether this is a realistic scenario and if so, what measures would be necessary to deal with potential conflicts.

Diagnosing the source of interference

A6.35 As described above, we currently receive complaints from viewers regarding interference to television and radio reception. We then decide whether to carry out an investigation. In some cases, we will suggest that the viewer contacts their equipment dealer or installer, who may be able to diagnose the problem. We incur costs for investigating and correcting interference, which, in some cases, can be recovered from the viewer.

A6.36 We are considering what types of investigation would be possible and appropriate in the future in order to diagnose and establish the cause of interference problems. We do not consider that it will be possible for residents to determine the cause of interference without some assistance.

A6.37 As is the case now, it is likely that some reception problems could be resolved by the viewer arranging to re-point their aerial to an alternative transmitter. In these situations, we may therefore refer viewers to their aerial installer. If this does not result in the interference lessening or ceasing, we expect that residents will revert to us for further assistance

A6.38 At this point, we are likely to carry out an assessment of transmission information held by us in order to come to an initial view on what networks or transmissions may be the cause of the problem. One option would be for us to contact the licensees who are potentially causing the interference prior to a site visit to inform them of the issue. We could also check if they are happy for us to correct the interference issue where possible on the initial visit by, for example, installing a filter. We further consider how we could prevent interference in the next sub-section.

A6.39 For a full assessment of the interference problem, a site visit will be needed. Diagnostic tools will be used to detect the source of the problem, which, combined with Ofcom's knowledge of transmitter sites and types of network being installed, will enable us to come to a view on the likely cause of the interference.

A6.40 If the site visit indicates that the interference is not caused by licensee's transmissions, our visit would be carried out on similar terms to that carried out today, i.e. if the interference is caused by the householder's own installation or domestic electrical system, we will charge a fee to the householder.

Preventing interference

A6.41 The aim as far as possible is to put the economic cost of addressing DTT receiver interference onto the licensee causing that interference. However, it is not appropriate that the costs of correcting interference fall on any new entrant licensee until it is clear which licensee is actually causing the interference. Under current arrangements, we both investigate and correct, where possible, during one visit, e.g. where the fitting of a filter can deal with the interference being experienced. We do (in most cases) charge viewers for this service.

A6.42 Our strawman protection clause proposal includes the requirement for licensees to cover the cost of correcting interference that they cause. Therefore, we need to consider whether appropriate arrangements can be put in place to enable Ofcom personnel to correct a problem while ensuring that the cost of correction falls on the licensee causing the problem. The proposed approach to the protection clause is that it is for the licensee to determine which correction method is appropriate. Retaining the existing approach to investigation and potential correction would limit the licensee's choice of correction method, although it appears to provide a more efficient mechanism for dealing with the issue from the viewer perspective.

A6.43 As mentioned in the previous sub-section, it may be possible for Ofcom and the licensee to discuss potential correction methods in advance of the site visit. For example, assuming that a sufficiently robust diagnosis could be made off-site, a licensee could indicate to us that a filter would be appropriate and even provide that filter. Where the initial diagnosis is confirmed on-site, we could install the filter and correct the fault.

A6.44 In such a situation, we would effectively be providing an interference service to the licensee and it may be appropriate for us to charge the licensee for the costs we incur in providing this service. This would be different from the current situation, where installation of a filter would entitle us to levy a charge on the viewer.

A6.45 Where a filter will not prevent interference, the method used by the licensee will depend upon a combination of technical and financial implications. An example might be to move the interfering transmitter.

A6.46 This means of correction may take some time, e.g. in finding premises, obtaining planning permission and installation and testing. While not wishing to unduly constrain the licensee's choice of remedies, we propose to impose a time limit on licensees' correcting interference issues to ensure that viewers affected by interference are not left with a degraded service for a substantial period of time. This may mean that the licensee is required to find a temporary means of dealing with interference whilst a transmitter is moved.

A6.47 We would like to explore with stakeholders an appropriate time limit and any temporary measures that could be put in place (e.g. filters).

A6.48 We consider that as a last resort, it could be appropriate for the licensee to cover the cost of the resident moving to another digital service where the licensee does not consider that any other options are viable, either for technical or economic reasons. Guidance would be produced addressing how this payment could be calculated.

A6.49 As it would be for the licensee to determine which remedial method was appropriate to meet their protection clause obligation, it follows that a resident would not be able

to refuse a payment and could not insist on a different interference remedy. Residents would also not be able to directly enforce the payment to them of replacement service costs or choose this method.

A6.50 Ofcom considers that by working with stakeholders, including industry and consumer groups, guidance can be produced for licensees detailing how the substitute service cost could be calculated.

Enforcement

A6.51 We are also considering an appropriate enforcement policy for the protection clause. It may not be proportionate in all cases to prosecute for non-compliance. We could include a materiality threshold e.g. in terms of the number of viewers whose interference issues have not been addressed within the specified time, or we could include a specific mechanism in the WT Act licence enabling revocation or variation on the occurrence of certain events, e.g. a failure to correct interference in these circumstances.

Annex 7

Interference between new services in the cleared spectrum

Introduction

A7.1 In section 5, we described our proposals for addressing potential interference between new services in the cleared spectrum. These proposals have been derived principally from technical work undertaken on our behalf which we have previously published with the DDR Statement[74]. We note that we cannot be exact in determining the precise guard-bands required to separate the different licences prior to the spectrum award. Without detailed knowledge of the transmission networks that are to be rolled out a number of generalisations and assumptions are required. Neither is the technical work on which our proposals are based exhaustive in detail at this stage. For this reason we recognise that there may be areas where further information could be beneficial in determining the most suitable guard-band sizes and we welcome views from stakeholders.

A7.2 As stated in section 5, in most cases, our approach has been to propose standard TLCs for each usage type, coupled with a judgement on the appropriate guard-band to address the risk of interference. Where a judgement on guard-bands has assumed TLCs that are different to the standard TLCs for a given usage type, this is highlighted.

A7.3 We present each of the interference cases for potential spectrum neighbour combinations in turn. Further detail may be found in our consultants' reports.

Interference between neighbouring FDD and TDD licensees, and neighbouring TDD licensees

A7.4 We describe here the basis for our proposal to adopt a 5 MHz guard-band coupled with more restrictive TLCs to ensure base station to base station interference may be prevented using reasonable coordination measures.

A7.5 In our 2.6 GHz award statement[75], we set out the rationale for an appropriate guard-band separating different operators of base stations and for the choice of TLCs which would restrict base station to base station interference. For the latter, the proposals were made based upon ensuring a reasonable "coordination distance" of 100m for macro base-stations, enabling uncoordinated base station deployment at separations of greater than 100m. In summary, the proposals were:

- TLCs based upon a standard base station in-band mean EIRP in line with 3GPP TS 25.104 for wide-area base stations.
- A 5 MHz "restricted block" at each frequency boundary separating paired (FDD) and unpaired (TDD) spectrum and at boundaries separating licensees of unpaired (TDD) spectrum. As well as serving the function of separating those at risk of base station to base station interference, in the 2.6 GHz award these

[74] http://www.ofcom.org.uk/consult/condocs/ddr/statement/
[75] http://www.ofcom.org.uk/consult/condocs/2ghzrules/statementim/statement/statement.pdf

"restricted blocks" have a lower (but non zero) EIRP limit, which is awarded to one licensee for use for lower power services.

- Where there is a possibility of base station interference into a neighbouring licensee's base station, the interfering base station will be subject to a "baseline" block-edge mask (BEM) which falls to −45 dBm/MHz in the adjacent channel, corresponding to an adjacent channel leakage ratio (ACLR) of 99 dB for high-power base stations.

- Emissions from neighbouring base stations into "restricted blocks" are restricted in line with the emission mask specified in 3GPP TS 25.104 for wide-area base stations.

A7.6 In the 2.6 GHz award, a 5 MHz "restricted block" was adopted, which as well as providing frequency separation between potential interferers, could be used for lower power services – for example femto cellular services. In the DDR we do not propose such restricted channels. In line with our discussion in section 5, we propose that the 5 MHz separating base stations of different operators is a guard-band, i.e. it has zero or noise like emission restrictions. This guard-band would be part owned by each neighbour, allowing post award negotiation between the neighbouring parties to make use of the guard-band should they decide this is beneficial, subject to approval of increasing the restricted emission level by Ofcom.

A7.7 With this one exception, we propose to adopt the 2.6 GHz award approach to the technical conditions for TDD and FDD services in the DDR cleared award. This means that, in cases where base station to base station interference may occur, TLCs will be different to the standard TLCs presented in Annex 10. Clearly there are a number of differences between 2.6 GHz and DDR cleared award spectrum which mean that key assumptions may not transpose exactly between the two awards. For example, the additional improvement via filtering required may be slightly greater at this lower frequency. Conversely, it may be slightly easier to achieve an increased level of performance through filtering at this lower frequency. In the absence of more detailed information at this stage we have adopted the values assumed in the 2.6 GHz award for instances where base-station to base-station interference could occur in the DDR cleared award, of which the principal elements are:

- a 5 MHz guard-band at each frequency boundary separating FDD lots and TDD lots, and at boundaries separating different licensees of unpaired TDD spectrum. These guard-bands will be part owned by each frequency neighbour and have noise like emission restrictions.

- where there is a possibility of base station interference into a neighbouring licensee's base station, the interfering base station will be subject to an emission restriction which falls to −45 dBm/MHz in the channel of the interfered party. This is beyond that imposed by the mask specified in 3GPP TS 25.104 for wide-area base stations. An implication of this is that out-of-band emission levels may need to be specified over a wide frequency range – for example in the 2.6 GHz award out-of-band emission levels were specified across the entire frequency range awarded.

Interference between DTT and MMS licensees

A7.8 Work undertaken by Aegis[76], which was published alongside our statement in December 2007, investigated the potential for interference to arise from the deployment of MMS services in channel 36 into neighbouring analogue services, i.e. in the immediately adjacent 8 MHz channels with no guard-band. In summary, this concluded that an un-coordinated deployment of MMS in channel 36 could result in around 15% of analogue coverage being impacted, equating to around 3% of the population within the coverage area.

A7.9 This work also looked at the impact if the neighbouring service was DTT rather than analogue. In this instance the improved protection ratio of DVB-T compared to PAL suggested a smaller, but still significant interference impact. The work suggested that around 3.4% of DTT coverage could be affected by MMS interference from the adjacent channel, equating to around 0.7% of the population within the coverage area.

A7.10 We have commissioned further work by Aegis to give an indication of the impact of interference from MMS into DTT for a range of C/I protection ratios were guard-bands to be introduced to separate the different services[77].

A7.11 In summary, this shows that, for main station DVB-T transmitters, the overall failure rates averaged across the coverage area of the DVB-T transmitter reduce from 2.85% with no guard-band (i.e. a protection ratio of -30 dB) to 0.06% with a 16 MHz guard band (i.e. a protection ratio of -54 dB).[78]

A7.12 In terms of population, these figures equate to DVB-H use without a guard-band potentially causing interference to between 0.21% - 0.86% of households, This percentage drops to between 0.004% - 0.017% when a 16 MHz guard-band separates the MMS and DTT services.

A7.13 These results can only be indicative as we cannot predict the details of the network deployments of either the new MMS or DTT licensees. In the absence of any detailed information on transmissions and coverage that may be utilised we propose that interference to less than 0.5% of households is used as a criterion for definition of an appropriate guard-band size to separate DTT and MMS services. Taking the worst case results reported in the calculations (based on the Lichfield transmitter), less than 0.5% households are potentially affected by the MMS services assuming a protection ratio of -36 dB. This equates to a guard-band between 0 and 8 MHz.

A7.14 On the basis of this information, we propose a guard-band of 5 MHz is adopted to separate DTT and MMS licensees in the cleared spectrum. On the basis of the technical work to date this suggests that less than 0.5% of households will be affected by interference from MMS, and potentially significantly less.

[76] http://www.ofcom.org.uk/consult/condocs/ddr/statement/Aegis1.pdf
[77] http://www.ofcom.org.uk/consult/condocs/clearedaward/aegis.pdf
[78] Previously published work (http://www.ofcom.org.uk/consult/condocs/ddr/statement/ERA2.pdf) has characterised the variation of protection ratio of DVB-H interference into DVB-T services as a function of frequency offset. A protection ratio of -30 dB equates to adjacent channel interference and a protection ratio of -54 dB equates to a 16 MHz guard-band separating the services.

Interference between DTT and FDD downlink licensees

A7.15 Work undertaken by Mason[79], published alongside our statement in December 2007, investigated the potential for interference to arise between DTT and UMTS downlink services. This work looked at interference arising both into DTT from UMTS and also into UMTS from DTT.

A7.16 In summary, the results suggest that with a 5 MHz guard-band, UMTS base stations have the potential to cause interference to neighbouring DVB-T reception - around 2% of DVB-T receivers could potentially suffer interference. Around 20 dB of mitigation would be required to provide 100% interference free DVB-T reception, or around 9 dB of mitigation to provide 99.5% DVB-T reception. A number of mitigation strategies are available to the mobile operator, including careful antenna pointing and improved transmit filtering. This is discussed in further detail in the report.

A7.17 The work also considers the interference from DTT into UMTS. In summary, it suggests that, with both 5 MHz and 10 MHz guard bands, a significant number of UMTS base-stations could be affected by interference from DTT. With a 5 MHz separation, around 33 dB of mitigation would be required at some base stations. Wider guard-bands produce little improvement because there is little improvement in the assumed protection ratios beyond the 5 MHz point. A 10 MHz guard-band would still require 30 dB of mitigation.

A7.18 Consideration of mobile uplink into DTT (described in the following two sub-sections) results in a proposal for a 16 MHz guard-band. This proposal would result in UMTS base station reception enjoying considerably greater frequency separation than that considered in this study, suggesting significantly less than 30 dB mitigation may be required. Should further mitigation at the UMTS base station be required, further work undertaken as part of the 2.6 GHz award has looked at the cost of providing improved base station filtering. This has concluded that significant improvements in both Adjacent Channel Selectivity (ACS) and ACLR are achievable at relatively low cost.

A7.19 On the basis of these considerations, we propose a 5 MHz guard-band to separate DTT licensees from FDD downlink licensees. This guard-band will in itself provide some, but not complete, protection from interference from the neighbouring service. Mitigation strategies may be required to further reduce the potential risk of interference, which could include improved base station filtering or improved DTT receiver filtering.

Interference between DTT and FDD uplink licensees

A7.20 We discuss this issue in detail in Annex 8, looking at potential interference from FDD and TDD mobile handsets into DTT reception.

A7.21 We propose a guard-band of 16 MHz is required to provide full protection to existing DTT receivers from interference. This is based on the potential for mobile handsets to cause blocking to existing DTT receivers which have relatively poor out-of-band rejection performance.

A7.22 Similar considerations apply with respect to new DTT and FDD licensees. We therefore propose a 16 MHz guard-band to separate DTT and FDD uplink licensees.

[79] http://www.ofcom.org.uk/consult/condocs/ddr/statement/Mason1.pdf

Interference between DTT and TDD licensees

A7.23 In considering adjacent DTT and TDD services there are a number of interference mechanisms to consider due to the potential for TDD uplink and downlink to cause interference to DTT, and equally, be victims of interference from DTT. The interference mechanism which dominates in considering the appropriate guard-band to separate services is mobile uplink into DTT receivers.

A7.24 Therefore, as with the previous case of interference between FDD uplink and DTT services, and as discussed in Annex 8, we propose a 16 MHz guard-band to separate DTT and TDD services.

Interference between MMS and FDD licensees

A7.25 Work undertaken by Mason[80] for Ofcom has investigated the impact of interference between MMS and FDD services. There are a number of interference mechanisms to consider in making judgements on appropriate guard-bands:

- interference from FDD base stations into MMS receivers (affecting the spacing between the MMS licence and the FDD downlink licence);
- interference from MMS transmitters into mobile FDD handset reception (affecting the spacing between the MMS licence and the FDD downlink licence);
- interference from MMS transmitters into FDD base station reception (affecting the spacing between the MMS licence and the FDD uplink licence);
- interference from mobile FDD handsets into MMS receivers (affecting the spacing between the MMS licence and the FDD uplink licence).

A7.26 We summarise these cases below, starting with the considerations relevant to a guard-band separating FDD uplink licensees and MMS licensees, and followed by the considerations for FDD downlink licensees and MMS licensees.

Interference between FDD uplink and MMS licensees

A7.27 The results presented in the Mason report suggest that UMTS UE transmissions will cause interference into nearby MMS receivers. If a UMTS UE transmits at full power, it may interfere with an MMS receiver tens or hundreds of metres away, depending on the guard-band separating the services. This is similar to the case of UMTS UE emissions potentially interfering with DTT receivers, which we discuss in Annex 8. There, we suggest a 5m separation distance as a basis for establishing suitable guard-bands. Clearly, a separation distance of many tens of metres leaves a significant risk of interference from handsets in close proximity to the MMS receiver. However planning on the basis of extremely small separation distances may be overly cautious. We therefore assume the same separation distance of 5m as a basis for establishing a suitable guard-band between UMTS UE and MMS receivers.

A7.28 A minimum coupling loss analysis suggests that with a 24 MHz separation of carrier frequency centres (equating to an 18.5 MHz guard-band), the separation distance drops to less than 5m even in the most extreme case of full power UMTS UE transmission. The separation distance drops further for the case where UMTS UE

[80] http://www.ofcom.org.uk/consult/condocs/ddr/statement/Mason1.pdf

emissions are not at maximum power (to around 2m in the case of mobile UE emissions being 6 dB less than maximum power).

A7.29 On this basis a guard-band of 19 MHz between FDD uplink and MMS licensees would be necessary to mitigate the risk of interference to that which is acceptable.

A7.30 In the case of MMS transmissions interfering with UMTS base station reception, results show that mitigation may be required at a percentage of UMTS base stations to overcome interference from MMS transmitters if the two networks are not coordinated. The level required depends on the frequency separation between the MMS transmitters and the UMTS uplink channel. In the worst case of no guard-band separating the different services, an additional isolation requirement of up to 50 dB may be required to overcome interference. The results suggest that this drops to around 40 dB if a 10 MHz guard-band is considered. Elsewhere, we have assumed that this level of mitigation may be achieved at relatively low cost in comparison to the total cost of base station equipment, for example by employing additional receiver filtering. Furthermore, since the guard-band is likely to be defined by the preceding case of interference from UMTS UE into MMS receivers, resulting in the 19 MHz separation suggested above, the mitigation required is likely to be less than 40 dB.

A7.31 Considering both mechanisms of interference discussed above, we propose a 19 MHz guard-band to separate FDD uplink and MMS licensees. The technical work suggests that this will, in the worst case, enable FDD and MMS handsets to coexist within 5m of each other, and in many cases substantially less. There may be a requirement for some additional mitigation of interference at UMTS base stations, for example by employing additional filtering, but the cost of such filters if required are not expected to be high in proportion with the costs of network roll-out.

Interference between FDD downlink and MMS licensees

A7.32 Considering interference into MMS receivers from mobile base station transmissions, the work undertaken suggests that, with no guard band, around 25% of MMS receivers could suffer from interference from base stations. Employing a 5 MHz guard-band reduces this level considerably to less than 5% of receivers affected, and employing a 10 MHz guard-band reduces this level slightly further (to approximately around 3%).

A7.33 The study suggests significant levels of mitigation may be necessary to restore MMS reception completely. Around 22 dB of further mitigation will be required in the case of a 5 MHz guard-band to restore 99.5% of MMS reception, or 50 dB of further mitigation to restore 100% of MMS reception. This may be achievable if cooperative practices are adopted by the adjacent licensees, for example, through improved base station transmit filtering.

A7.34 In the case of MMS transmissions causing interference to UMTS downlink (UMTS UE reception) the results from the study suggest around 7% capacity loss to the UMTS network in the urban scenario modelled, assuming a guard-band of 3 MHz separating the different services. It is noted in the study that results obtained in the MMS to UMTS mobile scenario are heavily dependent on assumptions used, in particular the propagation model assumed for the determination of cell sizes of MMS and UMTS. Further work may be beneficial in order to review alternative assumptions more fully, particularly for MMS. It is also noted that the results illustrate that MMS network design assumptions can have a significant impact on

the predicted UMTS network capacity loss, suggesting that coordination between MMS and UMTS operators in practice may be required.

A7.35 This is not a conclusive basis for making a judgement on the appropriate guard-band size. In the absence of further detail on network design assumptions or further technical work we propose a guard-band of 5 MHz. We recognise that the existing work suggests this has the potential to cause some capacity loss in the UMTS downlink channel in areas where interference from MMS might occur, and that a percentage of DVB-H receivers may be affected by UMTS interference. However, we must balance this with our duty to ensure efficient utilisation of the spectrum. We recognise we have little basis currently to propose a larger guard-band, and that the improvements that may be accrued through increasing guard-band size alone may be relatively modest, potentially sterilising a valuable spectrum channel for little benefit. For example, the reduction in the percentage of MMS receivers suffering interference is relatively modest when using a 10 MHz guard-band instead of 5 MHz.

Interference between MMS and TDD licensees

A7.36 Work undertaken by Aegis for Ofcom has investigated the impact of interference between MMS and TDD services. Again, there are a number of interference mechanisms to consider in making judgements on appropriate guard-bands to address the risk of interference. Full detail is given in the Aegis report.

A7.37 In the previous sub-section looking at interference between MMS and FDD services, it was established that the requirement to prevent interference from FDD UE emissions into MMS receivers resulted in a large guard-band. A minimum coupling loss analysis suggested that around 19 MHz was required to enable devices to work within a few metres of each other. We can expect a similar requirement in the case of WiMAX SS (Subscriber Station) transmissions causing interference into MMS receivers.

A7.38 The Aegis analysis of interference from a single WiMAX SS into a DVB-H receiver suggests that the required minimum separation distance varies between 82m and 212m when the guard band varies between 7 MHz and 0 MHz. This is also based on a free space path loss assumption.

A7.39 We propose that the same guard-band, i.e. 19 MHz, is adopted to separate MMS receivers from WiMAX SS emissions as was proposed in the previous sub-section to separate MMS receivers from FDD UE emissions.

A7.40 Regarding interference from MMS into TDD, the Aegis work suggests that the probability of DVB-H interference into mobile WiMAX SS receivers increases from 15.84% to 32.45% when the guard band is reduced from 6 MHz to 0 MHz. In the case of interference into mobile WiMAX base station receivers, the receiver noise floor is raised significantly (up to around 100 dB) due to the DVB-H transmitter interference. This suggests that, even with the proposal of a large guard-band of 19 MHz, there may still be a need for coordination and/or mitigation techniques.

Annex 8

Interference into and from existing DTT services – additional technical studies

Introduction

A8.1 In Annex 9 of the 2007 DDR Statement, we summarised the results of the technical modelling and practical measurement work carried out by consultants under contract to Ofcom[81]. We have subsequently commissioned additional technical work to further our understanding of interference issues between services, in particular into DTT services. This work has been used in support of our consideration of guard band requirements. This annex summarises the results of these studies.

ERA report: Conducted and radiated measurements to quantify DVB-T, UMTS and WiMAX interference into DTT

A8.2 In the 2007 DDR Statement, we published practical technical work carried out by ERA to consider interference into DVB-T services from other types of interferer[82] . The DTT receivers used in these tests were operating at low equivalent received field strength and carrier to noise (C/N) levels that broadly equated to edge of coverage DTT reception.

A8.3 We have since commissioned ERA to consider the impact of different types of interferer at different levels of wanted DTT signal up to a level where the DTT receiver would be overloaded[83]. The same averagely performing receiver used in the earlier testing was used. The effect of an aerial distribution amplifier on the susceptibility to interference was also tested. ERA examined through conductive measurement the impact on DTT failure point variation for interference from DVB-T, UMTS mobile uplinks and WiMAX, at separations of up to +/-11 channels (88 MHz) from the wanted DVB-T signal.

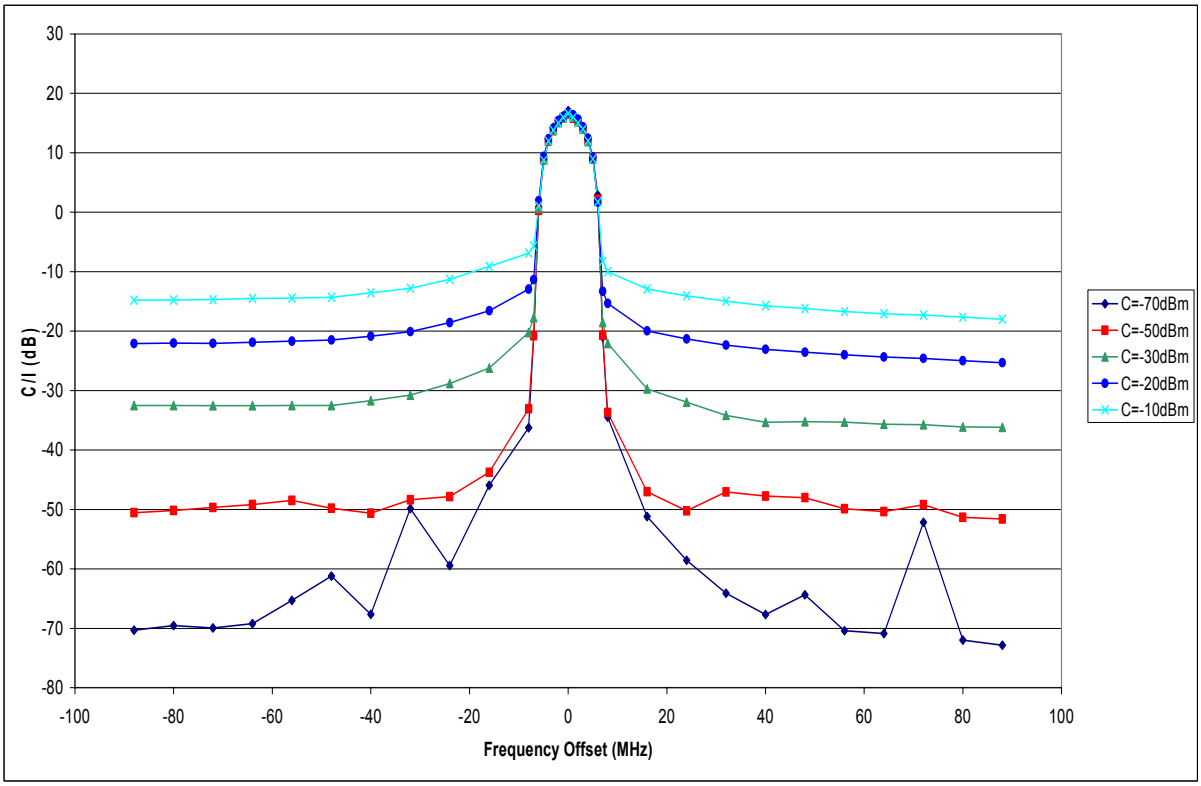
A8.4 For the baseline case of DVB-T into DVB-T, ERA concluded that as the level of the DVB-T wanted signal was increased from -70 to -10 dBm, the receiver gradually lost its ability to discriminate against interfering signals on the adjacent channels and further removed channels which could cause blocking. The DTT receiver is not capable of handling wanted or interfering signals once the levels go above -10 to 0 dBm. The consequence is that, for lower levels of wanted signal (-70 dBm), there is a larger dynamic range or 'headroom' for interference.

A8.5 When the wanted signal is high (-10 dBm), the receiver has very little dynamic range to reject any interference. When the DVB-T wanted signal increased from -70 to -10 dBm, an increase of 60 dB, an extra 35 dB of unwanted interfering power was required for the same level of adjacent channel DVB-T interference. This DVB-T unwanted level, relative to the DVB-T wanted signal, decreased to 8 dB under blocking conditions for interfering channels 40 MHz or more away from the DVB-T

[81] http://www.ofcom.org.uk/consult/condocs/ddr/statement/ddrannex.pdf
[82] http://www.ofcom.org.uk/consult/condocs/ddr/statement/ERA3.pdf
[83] http://www.ofcom.org.uk/consult/condocs/clearedaward/era.pdf

wanted channel frequency. Figure A8.1 below shows the C/I protection ratio as a function of frequency offset for different levels of wanted DVB-T signal.

Figure A8.1: Plot of C/I protection ratios for DVB-T interference into a typical DTT receiver operating at different power levels



A8.6 When a UMTS mobile uplink (or UE) interferer with transmit power control (TPC) was used as the interferer, the DVB-T receiver exhibited a similar failure profile to the DVB-T interferer case except that the UE required 7 to 10 dB less (mean) power to cause failure. This was attributed to the impulsive power spikes due to the TPC mechanism used by the UE to compensate for different propagation conditions.

A8.7 For testing using WiMAX as the interferer, ERA used a more advanced version of equipment than was available during the tests carried out in 2007. This later equipment was much closer in conformance to the draft IEEE 802.16e specification than the original system and it had a higher degree of configuration capability. In particular, a channel bandwidth of 5 MHz was selected (as more representative of a likely transmission bandwidth) compared to the fixed bandwidth of 20 MHz previously used.

A8.8 The WiMAX subscriber terminal was used as the interferer into DTT. ERA's results indicated that the DVB-T receiver exhibited a similar failure profile to that of the DVB-T interferer case except that the mean power required to cause failure was approximately 6 to 8 dB less than that required from a DVB-T interferer. This is similar to the UE case as WiMAX also incorporates a power control mechanism.

A8.9 ERA's results show that the use of an aerial distribution amplifier with a 10 dB gain reduced the level of interfering signal required (whether DVB-T, UE or WiMAX) to cause failure of the wanted DVB-T signal. This is particularly true at higher levels of wanted DVB-T signal where the receiver starts to become desensitised (above about -50 dBm)

A8.10 To complement the conductive measurements, radiated tests were performed to assess the impact of UE (with TPC) interference into a DVB-T receiver. To help determine guard band requirements, tests were performed with the UE antenna co-polar to and separated by 5m from the tip (boresight) of a typical Yagi TV antenna at the same height. The DVB-T receiver was operating at -70 dBm (approximating to edge of DTT coverage area) and the UE power was set to either 5 dBm with power control or 18 dBm without power control. This was considered to be a reasonable worst case scenario. The guard band required to prevent failure of the DVB-T signal was then determined both with and without a TV aerial distribution amplifier.

A8.11 ERA found that a maximum guard band of 21 MHz was required to protect a typically performing DTT receiver from a UMTS UE transmitting a mean power of 18 dBm with no transmit power control. A maximum guard band of 16 MHz was required to protect a typically performing DTT receiver from a UMTS UE transmitting a mean power of 5 dBm with transmit power control, for a wanted signal of -70 dBm.

A8.12 ERA reviewed the conducted measurements which suggested that there should be little difference in guard band between the UE operating at a mean power of 5 dBm with transmit power control or operating at a mean power of 18 dBm with no transmit power control. This guard band was measured to be 17 MHz with the addition of an aerial distribution amplifier. ERA concluded that the 4 to 5 MHz difference in guard band between the radiated and conducted measurements may have been due to the household TV cable having poor screening capability and therefore having an impact on the DTT receiver.

A8.13 If the wanted DVB-T signal was increased from -70 dBm to -50 dBm the guard band reduced to 3 MHz with the addition of an aerial distribution amplifier in the set-up.

A8.14 The guard band requirement as a function of distance between the UE and DTT receiver aerials was also considered by ERA. They found that a maximum guard band of 8 MHz was required from a UE operating at either a mean power of 5 dBm with TPC or 18 dBm without TPC at separation distances between 7 and 80m.

A8.15 Based on these conducted and radiated measurements performed by ERA, we have concluded that a suitable guard band between DVB-T and a UE would be 16 MHz.

A8.16 As ERA's conducted measurements indicate that WiMAX is very similar to (or slightly more benign than) a UE in terms of interference potential into DVB-T, we have concluded a guard band of 16 MHz is also appropriate for this case.

ERA report: Further assessment of DVB-T interference into WiMAX

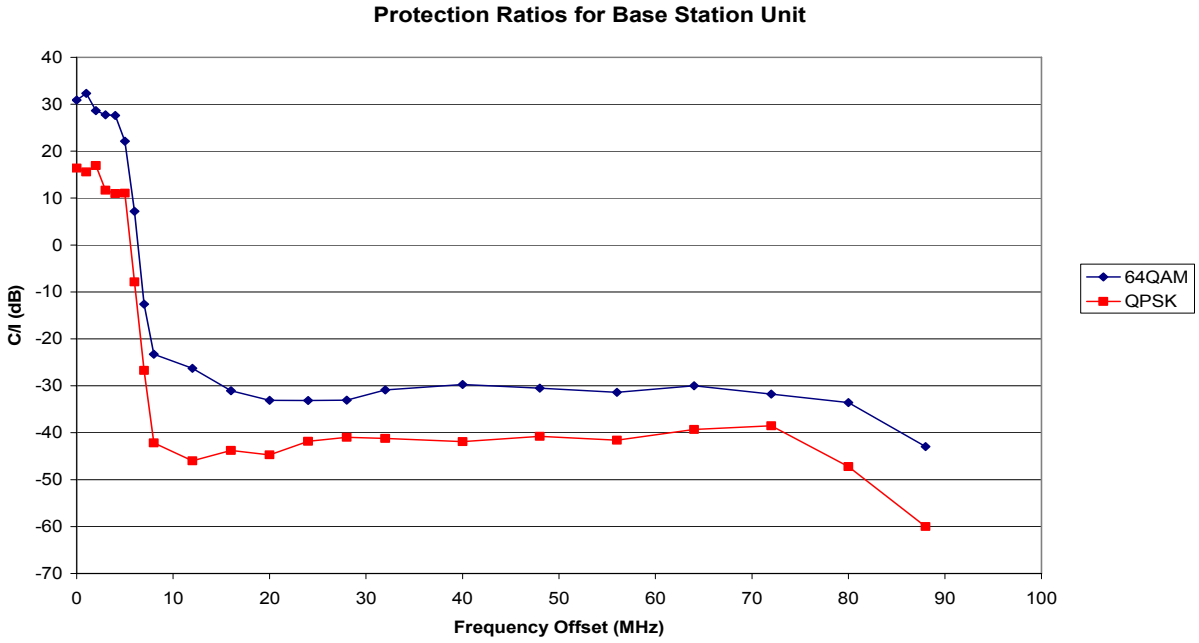
A8.17 In the 2007 DDR Statement, we published practical technical work carried out by ERA on behalf of Ofcom to assess the potential for interference into a range of technologies including UMTS, WiMAX, DVB-T and DVB-H[84]. At the time of testing, mobile WiMAX equipment was not readily available and so measurements were performed to assess DVB-T interference into a fixed WiMAX terminal conforming to IEEE 802.16-2004 standard.

[84] http://www.ofcom.org.uk/consult/condocs/ddr/statement/ERA3.pdf

A8.18 Since the testing, ERA has obtained new WiMAX equipment which, although still not fully conforming to the mobile WiMAX standard (IEEE 802.16e), allows much greater control and configuration of operating parameters. Ofcom commissioned ERA tests with this equipment to assess the carrier to interference (C/I) protection ratio requirements of WiMAX[85][. A 5 MHz bandwidth was used (considered as more representative of a likely transmission bandwidth compared to the fixed bandwidth of 20 MHz used in the earlier tests). A DVB-T signal operating at different frequency offsets from the centre frequency of the WiMAX signal was used as the interferer. Both the base station and the subscriber station were tested.

A8.19 WiMAX will automatically drop to a more robust modulation scheme/coding scheme (MCS) in the presence of noise. ERA selected the failure criteria as a drop in MCS and a corresponding drop in throughput data. The base station results are shown in Figure A8.2 below for both QPSK and 64 QAM modulation modes. In this case, failure was when 64 QAM3/4 dropped to 64 QAM2/3; and for QPSK when QPSK3/4 dropped to QPSK1/2.

Figure A8.2: Plot of C/I protection ratios for DVB-T interference into a WiMAX base station

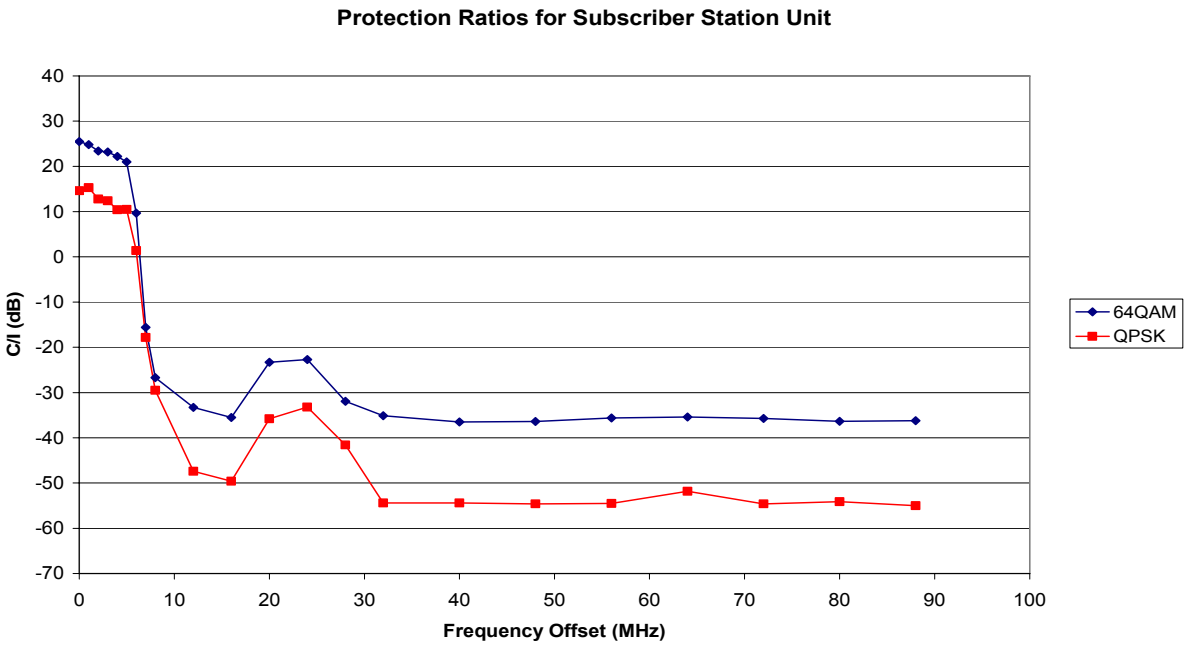


A8.20 The results show that QPSK3/4 is approximately 10 to 12 dB more robust than 64 QAM3/4 in the presence of a DVB-T interferer. The results also show the flatness of the C/I protection ratio profile with frequency offset, a feature ascribed to the relatively poor filtering used for WiMAX.

A8.21 For the subscriber station, the results are shown in Figure A8.3 below. The same MCS and failure criteria were used as for the base station case.

[85] http://www.ofcom.org.uk/consult/condocs/clearedaward/era_assessment.pdf

Figure A8.3: Plot of C/I protection ratios for DVB-T interference into a WiMAX subscriber station



A8.22 The results show that QPSK3/4 is approximately 10 to 15 dB more robust than 64 QAM3/4 in the presence of a DVB-T interferer. As in the base station case, the results also show the flatness of the C/I protection ratio profile with frequency offset. The subscriber station shows a greater sensitivity to DVB-T interference at a frequency offset of approximately 24 MHz. ERA considered that this may be due to image channel discrimination if the terminal uses superhet type design with an IF of 12 MHz; however, this has not been verified.

Aegis technical note: Interference from DVB-H into DVB-T

A8.23 In the 2007 DDR Statement, we published a technical report by Aegis considering DVB-H interference from a service in channel 36 into analogue TV and DVB-T systems[86]. This work primarily focused on the interference potential into the adjacent analogue TV channels used by Five.

A8.24 We commissioned Aegis to conduct further work to consider the impact of interference from DVB-H transmitters into DVB-T receivers for a range of assumed protection ratios[87]. This additional work was intended to provide guidance regarding the definition of a suitable TLC in the cleared spectrum that would be necessary to protect DTT services at the edges of the interleaved spectrum (channels 30 and 41).

A8.25 The same methodology was adopted by Aegis as used in the earlier study: a probabilistic approach using Monte Carlo simulation. An analysis of the failure of DVB-T services (through hole punching) as a function of C/I protection ratio in the range -30 to -54 dB was performed. An increase in C/I for the adjacent channel case (-30 dB) could be achieved by either improved filtering or guard bands.

[86] http://www.ofcom.org.uk/consult/condocs/ddr/statement/Aegis1.pdf
[87] http://www.ofcom.org.uk/consult/condocs/clearedaward/aegis.pdf

A8.26 The results of the analysis of DVB-H interference into DVB-T from 4 main transmitter sites in terms of population show that the overall failure rates are in the range of 0.21% to 0.86% when the protection ratio is -30 dB. The failure rate range is 0.004% to 0.017% when the protection ratio is assumed to be -54 dB.

A8.27 Results are also presented in terms of average failure rate across the DVB-T coverage area for both main and relay transmitters using representative operating parameters. The results show that interference into low power DVB-T transmitters operating as relay stations (with the same polarisation as used by the interfering DVB-H transmitters) within the coverage area is more severe than interference into high power main DVB-T transmitters (with opposite polarisation to that used by the interfering DVB-H transmitters) within the coverage area.

A8.28 For the main DVB-T transmitters, the overall failure rates averaged across the coverage area of the DVB-T transmitters reduce from 2.85% to 0.06% when the protection ratio is varied from -30 dB to -54 dB, for example by introducing guard bands. For the DVB-T relay stations, the overall failure rates reduce from 20.1% to 1.1% when the protection ratio is varied from -30 dB to -54 dB. Aegis concluded that the higher failure rates for relays would make it more desirable (than for the main transmitter case) for the DVB-H transmitter to be either co-located with the relay transmitter or separated by a guard band that may allow a high protection ratio to be achieved.

Annex 9

Interference between new services and international radio astronomy services

Background

A9.1 In the frequency range 608 - 614 MHz (in TV channel 38, 606 – 614 MHz), there is a secondary allocation to the Radio Astronomy Service used for observations in a number of European countries. The use of this band for the Radio Astronomy Service is addressed in the ITU Radio Regulations. The locations and modes of observation carried out by the UK's nearest neighbours are given in Table A9.1.

Table A9.1: Radio astronomy sites operating in channel 38 in neighbouring administrations

Radio astronomy site	Coordinates	Observation mode
The Netherlands, Westerbork	Long 06° 36'15" Lat 52° 55'01"	Single dish Interferometer VLBI
Germany, Effelsberg	Long 06° 53'00" Lat 50° 31'32"	Single dish VLBI
Belgium, Humain	Long 05° 15'19" Lat 50° 11'31"	Interferometer
France, Nançay	Long 02° 12'00" Lat 47° 23'00"	Single dish

Protection criteria

A9.2 ITU Recommendation ITU-R RA.769-2 provides the criteria to be applied when protecting the Radio Astronomy Service. Table A9.2 sets out the levels from ITU-R RA. 769-2.

Table A9.2: Protection levels for various observation modes as specified in ITU-R RA. 769-2

Observation mode	Protection levels
Single dish	-253 dB(W/m^{2}Hz) assuming an integration time of 2000 s
VLBI	-212 dB(W/m^{2}Hz) assuming an integration time of 10 μs
Interferometery	-236 dB(W/m^{2}Hz) assuming an integration time of 1 s

Protection of the Radio Astronomy Service from DVB-T and DVB-H

A9.3 ERC Report 85 details the compatibility assessment of DVB-T with the Radio Astronomy Service. The report gives the maximum co-channel and adjacent channel DVB-T field strengths that are allowed at a radio astronomy site in order to meet the protection criteria defined in ITU-R RA.769-2. These are shown in Table A9.3.

Table A9.3: Maximum allowed DVB-T interfering field strengths at radio astronomy sites

DVB-T channel	Single dish	Interferometery	VLBI
Co-channel (Ch 38)	-37.8 dBµV/m	-20.8 dBµV/m	3.2 dBµV/m
Adjacent channel (Ch 37)	31.8 dBµV/m	48.8 dBµV/m	72.8 dBµV/m
Adjacent channel (Ch 39)	2 dBµV/m	19 dBµV/m	43 dBµV/m

Separation distance

A9.4 Based on ERC Report 85, the separation distances between DVB-T transmitters and radio astronomy sites for channels, 37, 38 and 39 for the different radio astronomy observation modes were calculated for a reference DVB-T transmitter radiating at 1 kW (ERP) at 150m. These are given in Table A9.4.

A9.5 If 30 dB of mitigation is used (which can be achieved by using directional antennas, improved out-of-band filtering or other mitigation techniques), separation distances reduce considerably; these figures are shown in brackets in Table A9.4.

A9.6 Analysis for DVB-H assumed the same transmission filter characteristics as for DVB-T. Therefore, separation distances for DVB-H are the same as those for DVB-T, assuming the same reference transmitter characteristics.

Table A9.4: Separation distances[88] between a DVB-T transmitter and a radio astronomy site. Distances between parentheses apply when 30 dB of mitigation is used

	Separation distance (km)		
DVB-T/DVB-H channel	Single dish	Interferometery	VLBI
Co-channel (Ch 38)	797 (460)	606 (285)	340 (125)
Adjacent channel (Ch 37)	124 (37)	60 (20)	23 (5)
Adjacent channel (Ch 39)	351 (125)	208 (60)	75 (25)

.

Protection of RAS from FDD and TDD base stations

A9.7 The assumption is made that the UMTS900 system parameters are valid for IMT/UMTS in the UHF band. The UMTS900 base station reference technical specification is given in 3GPP TS 25.104. The spectrum emission mask values for the output power, P = 43 dBm were assumed.

[88] The separation distances were derived assuming land path only. If sea path is assumed, which should be the case when the path is over water, the separation distances will be greater. All separation distances in our analysis of interference into the Radio Astronomy Service assume land path only. The separation distances in Table A9.4 were based on a DVB-T or DVB-H transmitter of 1 kW ERP at a height of 150m.

A9.8 The FDD/TDD channel bandwidth is assumed to be 5 MHz. The centre frequency is 611 MHz for a base station operating co-channel with the Radio Astronomy Service, 603.5 MHz for channel 37 and 616.5 MHz for channel 39.

A9.9 The maximum co-channel and adjacent channel allowable interfering field strengths at a radio astronomy site are given in Table A9.5.

Table A9.5: Maximum allowed FDD/TDD base station interfering field strengths at radio astronomy sites

FDD/TDD base station channel	Single dish	Interferometery	VLBI
Co-channel within the Radio Astronomy Service allocation	-39 dBµV/m	-22 dBµV/m	2 dBµV/m
Adjacent channel (Ch 37)	-13 dBµV/m	4 dBµV/m	28 dBµV/m
Adjacent channel (Ch 39)	-17 dBµV/m	0 dBµV/m	24 dBµV/m

Separation distance

A9.10 The minimum separation distances between FDD/TDD base stations and the Radio Astronomy Service were derived using Recommendation ITU-R P.1546-2, and are given in Table A9.6. These distances have been estimated under the assumption that the value of the harmful interference threshold is exceeded for not more than 10% of the time[89] due to variable propagation conditions. In addition the following assumptions were also made:

- FDD/TDD base station radiated power = 30 dBW (EIRP)
- Transmitting antenna height = 30m
- Receiving antenna height = 50m
- Land path only

A9.11 Table A9.6 also shows that use of 30 dB of mitigation reduces the required separation distances (these figures are shown in brackets). Therefore, the use of channels 37 and 39 for FDD/TDD type of services would be more feasible but with potentially higher costs due to the need for mitigation.

Table A9.6: Separation distances[90] between an FDD/TDD base station and radio astronomy site. Separation distances shown in brackets apply when 30 dB of mitigation is used

	Separation distance (km)		
FDD/TDD base station channel	**Single dish**	**Interferometery**	**VLBI**
Co-channel within the Radio Astronomy Service	> 750 (430)	575 (280)	315 (95)

[89] Taken from Recommends 3 of ITU-R Recommendation RA.1031
[90] The separation distances were based on a FDD/TDD base station of 610 W ERP at a height of 30m.

allocation			
Adjacent channel (Ch 37)	475 (195)	300 (80)	120 (27)
Adjacent channel (Ch 39)	520 (225)	330 (130)	140 (35)

Protection of the Radio Astronomy Service from FDD and TDD user equipment (UE)

A9.12 Under the previous assumption that the UMTS900 system parameters are valid for IMT/UMTS in the cleared spectrum, the user equipment reference technical specification is 3GPP TS 25.101. For the purpose of our analysis, UEs were assumed to be operating at 200 mW.

A9.13 The maximum co-channel and adjacent channel allowable interfering field strengths at a radio astronomy site are given in Table A9.7.

Table A9.7: Maximum allowed FDD/TDD UE interfering field strengths at radio astronomy sites

FDD/TDD UE channel	Single dish	Interferometery	VLBI
Co-channel within the Radio Astronomy Service allocation	-39 dBµV/m	-22 dBµV/m	2 dBµV/m
Adjacent channel (Ch 37)	-7 dBµV/m	10 dBµV/m	34 dBµV/m
Adjacent channel (Ch 39)	-15 dBµV/m	2 dBµV/m	26 dBµV/m

Separation distance

A9.14 Due to the unique parameters associated with modelling mobile stations at low (1.5 m) antenna height into radio astronomy receivers at 50m, there are no appropriate propagation models. All available propagation models are limited to some degree and are not readily applicable to this scenario.

A9.15 However, by comparing the results of various propagation models it can be inferred that, for the adjacent channel conditions, separation distances are of the order of 100 km. Therefore, we believe it is unlikely that the operation of mobile stations would interfere with international radio astronomy services.

A9.16 For UEs operating co-channel with the Radio Astronomy Service allocation, indications are that separation distances are of the order of 300 km. Therefore, UEs operating in the East and South East of the UK may exceed the limits for single dish observation mode, especially if sea path is considered.

Use of channel 38

A9.17 In order to assess the geographic and technical restrictions on channel 38 when considering international radio astronomy services, a number of scenarios were modelled. A transmitter was modelled using ITU-R Recommendation P.1546-2 for the following parameters:

Table A9.8: Modelling parameters for assessing restrictions on Ch 38

Scenario	Power (Watts)	Transmitter height (metres)	Receiver height (metres)

1	10	10	50
2	1	10	50
3	0.2	10	50

A9.18 The above scenarios were modelled against the protection requirements for single dish observation mode at the radio astronomy sites given in Table A9.1 in order to provide indicative values on restrictions. It is recognised that ITU-R P.1546-2 is limited for this analysis but is useful for providing these indicative values.

A9.19 For Scenario 1, indications are that use is restricted to the west of a line running from Manchester to Bristol. Restrictions would also apply to the north east coast of England due to the radio astronomy site in the Netherlands.

A9.20 For Scenario 2, indications are that transmissions can be made in London.

A9.21 For Scenario 3, indications are that transmissions can be made for most of the UK with restrictions likely to be in the eastern parts of Norfolk, Suffolk and Essex.

Annex 10

Technical licence conditions in terms of SURs

Standard TLCs

A10.1 The standard TLCs in terms of SURs for the following lot types, DVB-T, DVB-H, FDD DL, FDD UL and TDD, are given in Tables A10.1 to A10.5. The SURs have been derived by Transfinite. The underlying assumptions and system parameters used in the modelling are given in the consultants' report[91].

A10.2 For the purpose of deriving the SUR parameters, it was assumed that a DVB-T or DVB-H channel occurred in the lower band (Ch 35) while an FDD or TDD channel occurred in the upper band (Ch 65). However this does not preclude the services under consideration from being used in other parts of the cleared spectrum.

Table A10.1: Standard SUR for DVB-T

	PFD at 1.5m [dBW/m^2/MHz]	PFD at 10m [dBW/m^2/MHz]
In-band PFD	- 81	- 65
Out-of-band PFD at the centre of adjacent channel	-141	- 125

Table A10.2: Standard SUR for MMS

	PFD at 1.5m [dBW/m^2/MHz]	PFD at 10m [dBW/m^2/MHz]
In-band PFD	- 54	- 38
Out-of-band PFD at the centre of adjacent channel	- 114	- 98

Table A10.3: Standard SUR for FDD downlink

	PFD at 1.5m [dBW/m^2/MHz]	PFD at 10m [dBW/m^2/MHz]
In-band PFD	- 60	- 42
Out-of-band PFD at 5 MHz offset from centre frequency	- 106	- 88

Table A10.4: Standard SUR for FDD uplink

	PFD at 1.5m [dBW/m^2/MHz]	PFD at 10m [dBW/m^2/MHz]
In-band PFD	- 81	- 63
Out-of-band PFD at 5 MHz	- 112	- 94

[91] http://www.ofcom.org.uk/consult/condocs/clearedaward/transfinite.pdf

offset from centre frequency		

Table A10.5: Standard SUR for TDD

	PFD at 1.5m [dBW/m^2/MHz]	PFD at 10m [dBW/m^2/MHz]
In-band PFD	- 59	- 41
Out-of-band PFD at 5 MHz offset from centre frequency	- 102	- 84

A10.3 All PFD (Power Flux Density) limits listed above should not be exceeded at more than 95% of locations (or test points[92]) in a test area[93].

A10.4 The PFD limit in a licence is set at the representative height(s) relevant to the receivers of the neighbouring licensees. The PFD limits listed in Tables A10.1 to A10.5 are given at heights of 1.5m and 10m. However, the receivers for the FDD UL and TDD (Base station receive mode) cases are at a representative height of 30m above ground level[94]. Hence, channels that are adjacent and/or near-adjacent to FDD UL or TDD channels have a PFD limit specified at 30m (in the case of FDD UL) and 1.5m and 30m (in the case of TDD). In areas where the local clutter is below 10m, the PFD value at 30m can be approximated to the PFD value at 10m.

A10.5 For the sake of simplicity, the out-of-band PFD limit in the above tables is given at a specific frequency. However in the actual licence, it is likely that the out-of-band PFD will be specified for a range of frequency offsets from the edge of the lot.

A10.6 In deriving the PFD limits, a particular lot size for each technology has been assumed: 5 MHz for FDD DL, FDD UL and TDD and 8 MHz for DVB-T and DVB-H. If the auction design allows for lot sizes of different bandwidths (likely to be for lots adjacent to a guard band), then the in-band and out-of-band PFD limits are the same as for the assumed lot size. However the out-of-band PFD limits are defined with respect to the edge of the appropriate lot.

A10.7 We note that where a TDD licensee is a frequency neighbour with another TDD licensee or an FDD licensee, a further restriction to standard TLCs is needed to manage the risk of base station to base station interference. Accordingly, for SUR-type TLCs, the relevant transmitting base stations would be subject to a standard SUR with an emission limit of -45 dBm/MHz in the channel of the interfered party.

[92] Test points are smaller locations within a test area. Their size will be set out in the licence and will typically depend on factors such as the resolution of the underlying mapping data. For example, a typical size for a test point can be 50m by 50m. In any test area, there may be hundreds or thousands of test points.

[93] The test area is an area covering at least 10 transmitters. Its size is determined based on how large it needs to be in any given location in order to enclose at least 10 transmitters, as set out in the SUR Statement. Generally, it can be expected to cover many square kilometres.

[94] See http://www.ofcom.org.uk/consult/condocs/clearedaward/transfinite.pdf

Annex 11

Glossary of abbreviations

3G	Third-generation mobile-phone standards and technology
AIP	Administered Incentive Pricing
BEM	Block-edge mask
CEPT	European Conference of Postal and Telecommunications Administrations
dB	Decibel
dBµV/m	Decibel microvolts per metre
DDR	Digital Dividend Review
DSO	Digital switchover
DTT	Digital terrestrial television
DVB-H	Digital Video Broadcast – Handheld
DVB-T/-T2	Digital Video Broadcast – Terrestrial
EU	European Union
FDD	Frequency-division duplexing
GE-06	Geneva 2006 Agreement
GHz	Gigahertz
HD	High definition
IMT	International mobile telecommunications
kW	Kilowatt
LTE	Long Term Evolution
MERLIN	Multi-Element, Radio Linked Interferometry Network
MFN	Multi-frequency network
MHz	Megahertz
MMS	Mobile multimedia services
MPEG	Moving Picture Experts Goup

mW	Milliwatt
PFD	Power Flux Density
PMSE	Programme-making and special events
PSB	Public-service broadcaster
RRC-06	Regional Radio Conference 2006
SD	Standard definition
SKA	Square Kilometre Array
STFC	Science and Technology Facilities Council
SURs	Spectrum Usage Rights
TPC	Transmit Power Control
TDD	Time-division duplexing
UE	User Equipment
UHF	Ultra-High Frequency
UMTS	Universal Mobile Telecommunications System
VLBI	Very Long Baseline Interferometer
W	Watt
WiMAX	Worldwide Interoperability for Microwave Access
WRC-07	World Radiocommunication Conference 2007