



Digital Dividend Review

This document consults on the proposed approach to the award of the digital dividend spectrum (470-862MHz)

Consultation

Publication date: 19 December 2006

Closing Date for Responses: 20 March 2007

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Alongside this document, Ofcom is also publishing online at www.ofcom.org.uk

- Further annexes to this consultation document (Annexes 6-13)
- Ofcom's market research
- A report by Analysys Consulting
- Other research, including reports on technical compatibility issues

Foreword

This review is about one of the most important decisions Ofcom has ever had to take – how to release the spectrum freed up by digital switchover for new uses.

The radio spectrum is a resource of fundamental importance in the modern world. It is the essential input into every type of wireless service – from satellites and radars to broadcasting and mobile communications.

In the UK, uses of the radio spectrum account for nearly one pound in every thirty in the economy, and its importance is growing fast. Consumers are using more and more wireless products, and innovators are competing faster and faster to supply them. But the radio spectrum is a scarce resource in very short supply, so how it is managed is a vital issue.

The digital dividend is, quite simply, one of the largest releases of valuable spectrum that is likely in the UK for many years. The spectrum is particularly useful because it is at lower frequencies – allowing large areas to be covered at lower cost, and helping signals to penetrate buildings.

Ofcom's primary duty is to further the interests of citizens and consumers. To do this, we are required to secure the optimal use of the spectrum. These key duties (among others) define our principal objective for the Digital Dividend Review - to maximise the value of the digital dividend to society.

So how should we go about achieving this goal?

To answer this question, we have looked in as much detail as we can at the different potential uses of the spectrum – and the different ways in which they could bring value to us as *citizens* as well as *consumers*. We have looked at potential sources of value to society, in applications as diverse as mobile broadband, local TV, and high definition television. This has included thinking about the ways that wireless services can contribute to our lives as citizens – ranging from community cohesion to cultural expression.

We have also thought deeply about the relationship between the choices to be made on the digital dividend, and a question that is still more profound – how should regulation be made fit for the digital age?

Our analysis is set out in this document. Two points stand out from the detail.

The first is that it is clear that there are very many different possible uses – and combinations of uses – of the digital dividend. We can be confident that the value of the resource as a whole is large, but there is significant uncertainty over the value of *individual* uses. This reflects, above all, the uncertainty that is inherent in fast-moving markets – where changes in technology and consumer preferences cannot be reliably foretold.

The implication of this point is simple but profound – we, as a regulator, simply cannot know the best uses of the digital dividend over the next couple of decades. What we can do is to create a framework that is more (or less) likely to enable those uses.

The second point is that there *are* some potential uses and users of the spectrum that could bring additional value to society, but that may not be able to earn commercial revenues to

correspond. But in each case this value to society could be delivered in a variety of different ways – some using the digital dividend, but some using other spectrum or other platforms.

Local television and high definition television are two cases in point. Our evidence suggests that local television could bring wider benefits to society, provided it is popular and not too local. But more and more platforms can now deliver local digital content, including wired broadband and satellite. These options all have different advantages – and all need to be considered by potential funders and operators.

The same is true of high definition television. It is possible that this will become the new standard for broadcasting – consumers may come to expect universal access to public service broadcasting in HD, just as they do now in colour. But the evidence for reaching a verdict on that claim now is lacking – most research suggests that HD is seen as a premium consumer product, rather than a significant source of value to society as a whole. Attitudes may change, of course, but we do not know how or when, and even if they do, there are many different ways of delivering HD – of which this spectrum is only one.

The implications of this second point are more complex:

- It is plainly vital that potential users of spectrum whose goals are social – like public service broadcasters – can get access to spectrum if this is the best way of meeting their objectives.
- But it is equally important that the decisions they make about which platforms to use, and which spectrum, don't get distorted by bad regulation.

What this requires can be stated simply. All potential users of spectrum need to have strong incentives to make the right choices about the spectrum they use – choices that are, so far as possible, good for society, not just good for the individual user.

We will get the *framework* for the digital dividend right if we get the *incentives* right.

In the past, successive regulators and Governments have used spectrum as a policy instrument – 'allocating' spectrum to preferred uses and users as a way of helping to secure the delivery of particular policy goals. Some have argued that we should take the same approach to the digital dividend – allocating spectrum to preferred uses or users that we should select.

But we do not think this approach is right or sustainable in the digital age. There are many reasons for this, but the most important concerns how we create the right framework with the right incentives for the best use of spectrum. If Ofcom picks preferred uses and users for this vital resource:

- We will distort incentives. Users who get preferred access to the spectrum will have less incentive to use it efficiently, and less incentive to look at alternatives.
- We will reduce flexibility. The more we pick preferred uses, the more we will constrain the use of spectrum to just those uses. This will limit the ability of users to respond – in a sector where there is constant, unpredictable innovation and change.
- We will have assumed that we, the regulator, can foresee the future. But we know we can't. We also know that the more we intervene in an area like this, the more likely we are to get it wrong.

So this document proposes that our approach to releasing the digital dividend should be to impose as few constraints as possible on how the spectrum can be used – and to give as much flexibility as possible to users to decide how the spectrum is used.

We also propose that, in almost all cases, the spectrum should be auctioned, and users should therefore pay the market price for using it.

This is a market-led approach, and it is consistent with the wider strategy towards spectrum that Ofcom has adopted since 2003. That strategy involves moving decisively away from command and control – with the regulator deciding who can use spectrum, how and for what – to give users flexibility, and limit regulation to what is essential.

The document also proposes that the right answer for organisations with broader social goals - like the Public Service Broadcasters - is *not* to intervene in the way spectrum is managed, any more than it is to 'allocate' them land or electricity.

Instead, the right answer lies in making sure these organisations operate in a financial and institutional framework that ensures that they can acquire spectrum, at auction or in the market, if this is the best use of their resources in securing public service objectives.

Our view is that work on this is an essential component of changing the way spectrum is managed. The Government recognised this in its response to the Independent Audit of Spectrum Holdings, which looked at public sector spectrum holdings outside broadcasting earlier in the year. We are committed to supporting the Government's work.

This document includes many other proposals that are important. To name just a few, it sets out our thoughts on:

- Deregulating the use of wireless microphones (which are important in public events such as sports and theatre), and managing the transition to new arrangements after switchover;
- Ways in which the spectrum could be packaged, to make it accessible to the many possible users, and create opportunities for both smaller and larger potential purchasers; and
- The timing and design of the proposed awards.

We warmly encourage all stakeholders to consider all the proposals carefully, and to respond to our consultation.

David Currie
Chairman

Ed Richards
Chief Executive

Section 1

Executive summary

- 1.1 The radio spectrum is a scarce resource of enormous importance in the modern world.
- 1.2 In the UK, uses of spectrum like mobile communications and broadcasting account for about 3% of the economy – more than the electricity and water industries combined. Spectrum is also an essential input into numerous public services – from defence to the emergency services, and from scientific research to transport.
- 1.3 The demand for spectrum is growing fast. In part, this reflects rapid innovation in wireless technologies and applications of many different kinds. In part, it stems from the fact that wireless services have unique features that are valued by almost everyone – like mobility and convenience.
- 1.4 The rising importance of the spectrum means that the way that it is managed is a vital issue for advanced economies around the world. So one of Ofcom's most important objectives is to ensure that the use of spectrum brings as many benefits as possible to the UK's citizens and consumers.
- 1.5 This consultation is about how we should achieve this through the release of one of the most valuable spectrum bands likely to be available in the foreseeable future – the digital dividend.

The digital dividend

- 1.6 As its name implies, the spectrum comprises a range of radio frequencies – from the very low to the very high. At very low frequencies, signals travel a long way, but they have little capacity to carry information; at very high frequencies, the signals do not travel far, but they can offer huge capacity.
- 1.7 The most attractive spectrum offers a combination of range (propagation) and capacity (bandwidth) that makes it suitable for lots of different uses. Good propagation means that less infrastructure is needed to provide coverage, which reduces cost and improves service in buildings and in rural areas. Good capacity means that the signals can be used for services that involve carrying lots of information to lots of users – like high-quality voice, data and video.
- 1.8 It is generally agreed that the most valuable spectrum in the UK is between around 200MHz and 1GHz – which offers just this combination of range and capacity. At present, nearly half of this spectrum is used to broadcast analogue television – 368MHz, or 46%, of the 800MHz.
- 1.9 The use of the spectrum for this purpose dates back to the decades after the Second World War, when television was first made available on a large scale and preparations were made for the introduction of broadcasting in colour. There were many fewer uses of spectrum then than now, and networks were generally optimised to economise on infrastructure rather than spectrum.
- 1.10 The UK's analogue television signals will be switched off, region by region, between 2008 and 2012. In principle, this means that all 368MHz might be available for new uses, but it was previously decided by the Government that 256MHz of the 368MHz

should be used for digital terrestrial television (DTT) from digital switchover. This digital broadcasting will be provided by six multiplexes, each of which can carry a number of television channels and some other services.

- 1.11 This decision will allow digital terrestrial television to expand its *coverage* – to match that of analogue, at 98.5% of the population; and its *capacity* – to around 10 times that of analogue in most of the country, and around 5 times elsewhere.
- 1.12 At the same time, digital switchover will allow the remaining spectrum – 112MHz – to be released for new uses. It is this 112MHz that forms the core of the ‘digital dividend’.

Different types of spectrum

- 1.13 In fact, there are three different sorts of spectrum that are available for release, and we have been considering all three in the Digital Dividend Review.
- 1.14 All of these frequencies are located in that part of the radio spectrum known as UHF, or Ultra High Frequency – a name that dates from the days when little use was made of higher frequencies. (That has long since changed, though UHF spectrum remains exceptionally useful.) The UHF band is conventionally divided in Europe into channels of 8MHz each, with the part often used for broadcasting ranging from channel 21 at the bottom to channel 69 at the top – or 470MHz to 862MHz.
- 1.15 The three sorts of spectrum are:
- the **112MHz** mentioned above. This comprises spectrum that will be **cleared** as a result of digital switchover, and that will be available UK-wide for new uses. This 112MHz comprises 14 channels of 8MHz, which is presently used for analogue television, and on a secondary basis for uses such as wireless microphones. Both primary and secondary uses will cease at switchover;
 - two **other blocks of spectrum** that are used for other things, but have the **potential to be cleared**. These are channel 36 and channel 69. Channel 36 is currently used for airport radar, and channel 69 principally for wireless microphones. In both cases, it was sensible to review the future use of this spectrum at the same time as the rest of the band. The inclusion of these two blocks means that there is a total of **128MHz** potentially available as cleared spectrum on a national basis; and
 - then there is **interleaved** spectrum. This is capacity that will be available within the frequencies that will be used to carry the six DTT multiplexes. It is effectively ‘white space’ that exists geographically between the transmitters needed for those six multiplexes.
- 1.16 These three categories of spectrum – the cleared, the potentially cleared, and the interleaved - are together referred to in this document to as the **available UHF spectrum** or, more loosely, as the **digital dividend**.

Potential uses and users

- 1.17 We have identified many possible uses for this spectrum. But it is important to recognise that we cannot identify *all* the possible uses. 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.

1.18 The main uses we can identify as possibilities now are:

- **mobile television** – and other types of mobile video and multimedia;
- **digital television** channels aimed at a national market; these could be in
 - **standard definition** (SD) like terrestrial services broadcast now, or in
 - **high definition** (HD);
- **digital television** channels aimed at a local market – **local television**;
- **wireless microphones**, and other programme-making and special events (PMSE) applications, like in-ear monitors;
- **broadband wireless** applications – which could also be mobile;
- **mobile communications** – services like voice and data;
- **low power applications** – like hubs to distribute content around the home;
- services using **satellite** communications; and
- **public safety services** – like applications for the emergency services.

1.19 But this is not an exhaustive list, and even within this list there is a huge array of variants that could affect the use of spectrum. These include different standards or technologies that could be used; different geographies that could be targeted; different services that could be offered; and different user groups that could be served.

1.20 As a result, among the issues covered in this document are the relevance of this spectrum to the **rural coverage** of many services; and the way in which enhanced television services could be provided to viewers with **particular requirements for accessibility**.

1.21 The question of who uses this spectrum is yet another dimension. There is an even wider array of **potential users** of the spectrum than there is of uses – many different operators of many different services. And it can be argued that the different character of these organisations could also be relevant – such as whether they belong to the public, private, or voluntary sector.

Objectives and approach

1.22 Our objective in releasing the digital dividend is to maximise the value that the use of this spectrum is likely to bring to society over time. It is emphatically 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 Ofcom takes into account.

1.23 The use of the radio spectrum has historically been highly controlled by regulators in the UK and around the world. Regulation has been “command and control” in style –

with the regulator controlling who may use the spectrum, what services they may provide, and what technologies they may use.

- 1.24 This highly intrusive approach is no longer fit for the modern age. Many studies have shown how excessive regulation of spectrum has led to extra scarcity and less flexibility. Both competition and innovation have been damaged – as new entrants and new technologies have both struggled to gain access to markets.
- 1.25 The use of spectrum is so important in the economy that excessive regulation has very large costs. One study for the European Commission has estimated that reducing spectrum regulation could bring extra benefits worth €9 billion every year to the EU economy¹. Other studies in the US have shown similarly large effects.
- 1.26 Since Ofcom came into existence at the end of 2003, we have pursued a vigorous agenda for reforming spectrum management – to allow users much more flexibility to decide how spectrum is used, for what and by whom. We are implementing this by reducing regulation and making much more use of market mechanisms:
- allowing spectrum to be traded from one user to another;
 - liberalising the use of spectrum, by removing restrictions that limit use to particular technologies or services;
 - releasing spectrum that is unused promptly to the market; and
 - cutting regulation, where appropriate, by reducing the need for licences to use spectrum.
- 1.27 At the same time, we recognise the fundamental responsibilities of regulation – to prevent one use of spectrum interfering harmfully with another, and to ensure fair and effective competition. We also recognise that in the past the way spectrum is used has been linked directly to public policy goals – and that the transition from one model of command and control, to another of market mechanisms, requires careful thought and preparation.
- 1.28 How do we maximise the value to society from the digital dividend? To help us answer this question, we have undertaken a very large amount of analysis and research over the course of this year. The results of that work are set out in this document, in the Annexes and in a number of accompanying documents.
- 1.29 The key components of our work have included: technical analysis of the ways in which the spectrum could be used; extensive research into consumers' interest in various potential uses; assessment of the potential demand for different services; modelling of the likely value of the spectrum to consumers and businesses and society more generally; and consideration of the options for packaging the spectrum and the design of an auction.

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http://ec.europa.eu/information_society/policy/radio_spectrum/docs/ref_docs/secontrad_study/secontrad_final.pdf

Analysis

1.30 Some key points stand out from the work we have done.

We know the value of the spectrum is large - but the value of any one use is uncertain

1.31 We estimate the total value of this spectrum to consumers and businesses at £5-10 billion, though the figures are uncertain. Note that this is not an estimate of auction proceeds, but a figure for the total value to consumers and businesses over 20 years (net present value).

1.32 But there is huge uncertainty over the value of the *individual* uses we have identified. This reflects, above all, the uncertainty that is inherent in fast-moving markets, where changes in technology and consumer preferences are unpredictable. This is quite apart from the uncertainty over uses that, as yet, are unknown.

1.33 There is also uncertainty over the technical feasibility of the different uses. We know that the use of the interleaved spectrum is much more constrained than the cleared spectrum – although even this has alternative uses (such as DTT with local or sub-national coverage, and low power devices such as wireless microphones).

1.34 We also know that there are some important technical constraints on use of the cleared spectrum given the need to protect services using adjacent channels in the UK (mainly reception of digital terrestrial TV), and to respect international agreements. In particular it is likely to be difficult to use some or all of the spectrum for mobile devices transmitting to networks (uplink). Just how difficult is not certain, but transmissions in the reverse, downlink, direction should be feasible, and it may be possible to use spectrum in neighbouring bands for any required uplink.

Wider value to society is a significant issue for some uses – less so for others

1.35 Throughout the project we have tried to identify all the different ways in which using the spectrum could create value to us both as consumers *and* as citizens – including value that it is difficult or impossible to quantify, such as potential contributions to broader social goals like community cohesion or cultural self-expression.

1.36 We have found that there *are* some potential uses of the spectrum that could bring broader value to society – value that might not be captured in an approach based solely on markets. Local television is one example. Our research with citizens and consumers suggested that local TV could bring broader value to society through better awareness of what is going on in a given community – though the level of actual commitment to watching it was not always clear.

1.37 Similar issues arise in relation to other services. The research showed people felt that widespread availability of mobile broadband could be of broader value to society, for example in rural areas. More choice on the DTT platform could also be beneficial to society if the content was good – the quality of content was seen as critical.

1.38 High definition television, by contrast, was not identified in our research as a major source of broader value to society. A bigger choice of channels was rated more highly, for both citizen and consumer interests, and HD was seen mainly as a premium consumer product, similar to mobile television.

- 1.39 It is possible, of course, that attitudes to an innovation like HD may change. In time, consumers and citizens may come to expect some HD content to be available to everyone free of charge, just as colour is now. But the evidence that this will happen is not strong right now.

Wider value to society can be delivered in many different ways

- 1.40 We also found, importantly, that there are alternative ways of delivering the value to society that could be provided by these services. Using the digital dividend is just one option among many.
- 1.41 For example, local television – and other types of local digital content – could be delivered by platforms like broadband and satellite. Terrestrial television is only one option. Mobile broadband, similarly, can be delivered using a wide range of different technologies and spectrum bands.
- 1.42 The story is the same for HD. All broadcasters have a range of options for making their services available in this format – this includes the PSB broadcasters who want to provide it free-to-view. The options for them include using the extra capacity created by improvements to DTT at digital switchover (equivalent to another multiplex); upgrading the DTT platform; and using free-to-view satellite – quite apart from new platforms like IPTV.
- 1.43 For any service, and any provider, each option will have its own costs, benefits, and complexities. We found as much uncertainty about the extent to which the digital dividend might bring broader value to society as we did on any other issue.

In short, it is not possible for us as the regulator to ‘know’ the best use

- 1.44 There is so much uncertainty about the current and future value of different uses of this spectrum to society, that we, as a regulator, simply cannot say with confidence what will be the best use of this spectrum over coming decades. To claim that we could would be wrong.

Strategic options

- 1.45 So what should we do, given this background?
- 1.46 In the past, successive regulators and Governments have used spectrum as an instrument of public policy. Spectrum has been ‘allocated’ to preferred uses and users as a way of helping to secure the delivery of particular policy goals, and responding to the risk of market failure. Other uses and users have been excluded, and the preferred user has usually had the benefit of access without having to pay a market price.
- 1.47 Some have argued that we should take a similar approach to the digital dividend – and that we should allocate the spectrum to the particular uses or users that they favour, in order to promote public policy goals.
- 1.48 We have considered these proposals carefully, but we do not think this approach is right or sustainable in the digital age. There are many reasons for this, but the most important concern how we, as a society, can derive the greatest benefits from this valuable resource over time.

- 1.49 Using spectrum as a policy instrument may have been appropriate when the variety of uses was less than it is today – and when there was little choice about how to secure value for society. But neither of these conditions now holds, and it is vital that we create a framework for using spectrum that encourages good decisions about how to use it – and good decisions about how to deliver public services.
- 1.50 Our analysis shows that if we pick preferred uses or users:
- we will distort incentives. The uses and users that get preferred access will have less incentive to use spectrum efficiently. They will tend to use too much, relative both to other potential users of the spectrum and their own use of other inputs to deliver services;
 - we will reduce flexibility. If we pick a preferred use and user when we award the spectrum, we will have to impose extra constraints on the way the spectrum is used. There will be less flexibility for the way that spectrum is used to change if circumstances change – for example if demand for the preferred use turns out to be less than expected, or alternative uses turn out to be more valuable;
 - we will risk distorting competition, because the preferred users may gain an advantage, and risk reducing the scope for innovation in uses that cannot get access to the spectrum; and
 - we will risk getting it wrong, by picking a use or user that turns out not to be the best. This risk is larger the more uncertainty there is in the decision.
- 1.51 We therefore favour releasing the spectrum in a way that imposes as few constraints on how it can be used as possible. Some constraints are unavoidable, to avoid interfering with other services and to meet international obligations. But these constraints apart, users should be free to decide *how* the spectrum should be used, for *what*, and by *whom*.
- 1.52 This is a market-led approach to spectrum, not a regulator-led one. But like all markets, the use of spectrum needs to be subject to some rules to ensure fair play. So we will, for example, be considering in detail how best to ensure that the release of this spectrum promotes competition in downstream markets. We will also look at whether to include conditions in licences that promote competition and guard against anti-competitive hoarding.
- 1.53 We have also given a lot of thought to two issues that we think do justify some intervention in a market-led approach. One is the problem of *transaction costs*: the fact that some valuable uses of spectrum involve thousands of users who individually use a small amount of spectrum, but for whom co-ordinating use could be very costly. This could be particularly relevant to some potential innovative uses. The other is the risk of *disruption* to existing users of spectrum: as most of the digital dividend will be cleared by DSO, this problem relates mainly to the many users of wireless microphones, who presently use the spectrum interleaved with analogue broadcasting. The implications of these points are discussed below.

Implications for policy

- 1.54 Our approach is consistent with Ofcom's strategy towards spectrum since 2003 – and with Government policy as stated on several occasions. It does, however, have some big implications for public policy.

- 1.55 This approach implies that we do not favour using preferred access to spectrum as a public policy tool for securing benefits for society – but it does not imply that those social benefits do not exist. Indeed, it is vital that those benefits can continue to be secured in a world where spectrum is a flexible, market-based resource.
- 1.56 But to make sure this happens, the financial and institutional framework for providing public services will need to recognise that the way spectrum is managed has changed. There are, for example, many public sector organisations that use spectrum as an input, from the Ministry of Defence to Public Service Broadcasters. The funding and governance of these organisations needs to recognise the potential need to acquire spectrum, if this is the best use of the resources available to them. The same may be true in other sectors – like voluntary organisations.
- 1.57 The need for this change was a key theme in the Government’s response to the Independent Audit of Spectrum Holdings published in March 2006. This endorsed the extension of a market-based approach to spectrum management across the entire public sector outside broadcasting – including uses such as defence and emergency services.
- 1.58 A major programme of work is now under way to implement the findings of this Audit. Our view is that the principles recommended by the Audit should be extended to cover all possible uses of the digital dividend, including national and local television.
- 1.59 Ofcom is fully committed to understanding the value that using the digital dividend spectrum could bring to society, in all its forms.

Individual uses

- 1.60 We have looked in detail at how to apply our strategic approach both as a whole, and in the context of each of the many potential uses of spectrum we can identify now.
- 1.61 Some key proposals that bear on individual uses are as follows:
- **wireless microphones for community use, and similar low power devices:** because there are many thousands of small, independent, users in this category, we propose to make available channel 69 for wireless microphones and similar low power devices such as in-ear monitors; we also propose to deregulate access to most or all of this spectrum, by making access free, on demand, to users, without the need for a licence;
 - **wireless microphones for professional use, and similar low power devices:** we recognise the risk of causing disruption to the large community of professional users of wireless microphones and similar low power devices such as in-ear monitors and talkback. This equipment is widely used in theatres, broadcasting and special events; so we will phase in changes to spectrum management here. The cleared spectrum will cease to be available as DSO occurs region by region across the country. This will require many users to retune their equipment or purchase new equipment to make use of different frequencies. However, we will ensure that spectrum continues to be available for this type of use from the new capacity that will exist interleaved with the six digital terrestrial multiplexes after switchover. We will ensure this continued availability for a transitional period, until at least 2012. We set out in this document different options for how this capacity could be packaged and released into the market, including by auction. We will work closely with the user community in developing these proposals and managing the transition to new arrangements;

- **potential low power uses:** we are keen to investigate other potential innovative uses of the spectrum, but so far we have received few specific proposals. We are seeking to gather more evidence through this consultation, so we can make a more informed judgement next year on whether additional spectrum should be set aside for possible low power uses. We are also undertaking a wider review of how to facilitate more licence-exempt use of spectrum;
- **local television:** local television is a likely use of the interleaved spectrum, but we think that making this spectrum available nationwide could make it difficult for potential local TV operators. So we propose to offer packages in the interleaved spectrum that are suitable for local TV. These could be geographical assignments based on main transmitter sites across the country. There could be 40 or more packages available, perhaps up to 100. We do not propose to limit use of this spectrum to just local TV, as there are other possible uses for this spectrum, and we propose to award the packages by auction; and
- **broadcasting and other uses:** we propose to package the cleared spectrum so that it is suitable for use by national DTT, for a variety of services including high definition; but other uses and users will also be able to acquire rights to use the spectrum – uses such as mobile television, wireless broadband, mobile voice and data, and new innovative applications that may emerge.

Timing

- 1.62 We plan to release all, or almost all, of the available UHF spectrum as soon as practical, so that the benefits of the spectrum to society can be realised as early as possible.
- 1.63 It is currently expected that the earliest date that an auction of the available spectrum could take place would be during the second half of 2008. This would allow for new services to be deployed in particular regions of the country as the analogue signal is switched off – without having to wait until DSO is finished in 2012.
- 1.64 We propose to integrate the award of channel 36 with the rest of the spectrum, unless awarding the latter is significantly delayed from the timing set out above. The reasons for this are twofold:
- before channel 36 can be used for any alternative applications, the existing user (airport radar) must vacate the spectrum and international negotiations must be concluded on the future use of the channel. As a result it is not likely that the spectrum will be free for new uses before late 2008; and
 - given that channel 36 is a strong substitute and complement for the other nationally available UHF spectrum (the cleared spectrum), it is likely to be more efficient to award all of this spectrum in one integrated award.
- 1.65 We are also inviting views on the case for holding back a small amount of spectrum – cleared or interleaved – as an “**innovation reserve**”. This would be against the possibility of major technological developments – such as new low power uses – that could find it difficult to access the rest of the spectrum, even if it has been licensed on a flexible basis.

Spectrum requirements and packaging

- 1.66 We plan to award all of the spectrum on a UK-wide basis, except for packages in the interleaved spectrum that would be suitable for local television.
- 1.67 There is a large number of potential options for packaging the cleared spectrum. We have set out six options which capture the range of possibilities, as follows:
- i - a single lot of all the cleared spectrum under consideration in the DDR;
 - ii - 3 lots : channels 31-37, 39-40 and 63-68;
 - iii - 4 lots: channels 31-34, 35-37, 39-40 and 63-68;
 - iv - 4 lots: channels 31-33 & 63-65, 34-37, 39-40 and 66-68;
 - v - 5 lots : channels 31-33, 34-37, 39-40, 63-65, and 66-68; and
 - vi - 15 x 8 MHz lots, being each of channels 31, 32, 33, 34, 35, 36, 37, 39, 40, 63, 64, 65, 66, 67 and 68.
- 1.68 We think that options iii, iv, v and vi are likely to be preferable, but we invite views from stakeholders on all the options. We will present more detailed packaging proposals in a consultation in or around July 2007.
- 1.69 In the interleaved spectrum, we propose to offer:
- 40 or more packages suitable for local television; these will comprise at least one assignment at each of a large number of main transmitter sites; and
 - packages of interleaved spectrum suitable for wireless microphones; these would be nationwide and we would ensure continued availability of spectrum for PMSE use at least until the end of 2012.

Potential auction designs

- 1.70 There are a number of different auction formats available, which may be suitable for the award of multiple lots of spectrum frequencies. In selecting the appropriate format for an auction, it is helpful to consider four key choices in design:
- simultaneous or sequential sale of lots;
 - single round (sealed bid) or multiple rounds (ascending bids);
 - generic or specific lots; and
 - individual lot or package (combinatorial) bidding.
- 1.71 Ofcom's current view is that using a simultaneous, multiple round process is likely to be the most appropriate approach for the cleared spectrum. We will give more thought to the options for the interleaved spectrum where a simpler mechanism may be preferable.

- 1.72 We also believe that it is likely to be more appropriate to use specific lots rather than generic lots, due to the differences in constraints (and hence usability) of the spectrum under consideration in the award.
- 1.73 However, we have not yet come to a view as to whether it would be appropriate to use package bidding in this award.
- 1.74 A number of potential auction formats are described, along with the advantages and disadvantages of each. Ofcom has not yet concluded on the appropriate auction design for this award, and will issue more detailed proposals for consultation in or around July 2007. The potential auction formats currently being considered are:
- a 'standard' simultaneous multiple round ascending auction (SMRA) with pre-defined lots, which could be augmented by either limited withdrawals or augmented switching;
 - a SMRA with pre-defined lots and package bidding;
 - a clock/sealed bid hybrid with each lot as a unique category (equivalent to having pre-defined lots); or
 - a clock/sealed bid hybrid with a more limited number of categories of generic lots.

Usage rights and obligations

- 1.75 The main non-technical conditions that Ofcom is currently minded to include in the licences to be issued for use of the UHF spectrum are:
- licence term – a minimum term of 18 years, with an indefinite term thereafter, subject to revocation on 5 years' notice; additional fees may be payable after the minimum term;
 - tradability – the licences to be tradable;
 - liberalisation – the licences to contain the minimum necessary technical conditions and not specify either type of equipment or services; and
 - obligations relating to PMSE – the obligation to make some interleaved capacity available for PMSE services.
- 1.76 We will also be considering how this spectrum award should take into account the 2012 London Olympics and Paralympics.

Citizens and consumers

- 1.77 We believe that the proposals set out in this document will deliver significant benefits to citizens and consumers. This is because we think that the right way to further the interests of citizens and consumers through the digital dividend is not to impose restrictive regulation on potential uses and users, which can impose very large hidden costs. Instead we propose to create as much flexibility as possible for spectrum to be used in the most efficient way.
- 1.78 Under this approach, a significant amount of valuable digital dividend spectrum will be made available for new services, which should bring benefits to consumers and citizens through a greater potential for innovation, greater flexibility to achieve the

best uses of the spectrum, and the potential to increase competition in communications markets.

Next steps

- 1.79 This consultation, published on 19 December 2006, lasts for 13 weeks. The closing date for responses is 20 March 2007.
- 1.80 We warmly welcome comments on these proposals. We recognise the complexity and importance of the issues, and we will conduct a substantial programme of stakeholder engagement during January and February 2007, to allow stakeholders to express their views on the proposals we have put forward.
- 1.81 Alongside this document, we are also publishing a number of supporting documents, including Annexes to this consultation document, a report by our consultants, the results of Ofcom's consumer market research, and a number of reports covering technical and compatibility issues. These are available on the Ofcom website at <http://www.ofcom.org.uk/consult/condocs/ddr/>.
- 1.82 We expect to release a statement on this consultation in or around July 2007. At about the same time, we also expect to publish a further consultation on some of the many detailed issues that will need to be addressed to take the award forward – such as detailed proposals on spectrum packaging and auction design.
- 1.83 An indicative timetable for the whole spectrum award is set out in Section 12. This timetable is subject to a number of external factors beyond Ofcom's control (eg international developments), and so may be amended during the course of the award process. In particular, it is possible that in time proposals may be made for action at European level on the digital dividend, including the possibility of decisions by European institutions that could be binding on the UK.

Question 1 : This executive summary sets out Ofcom's proposals for the release of the digital dividend. Do you agree with these proposals?

Section 2

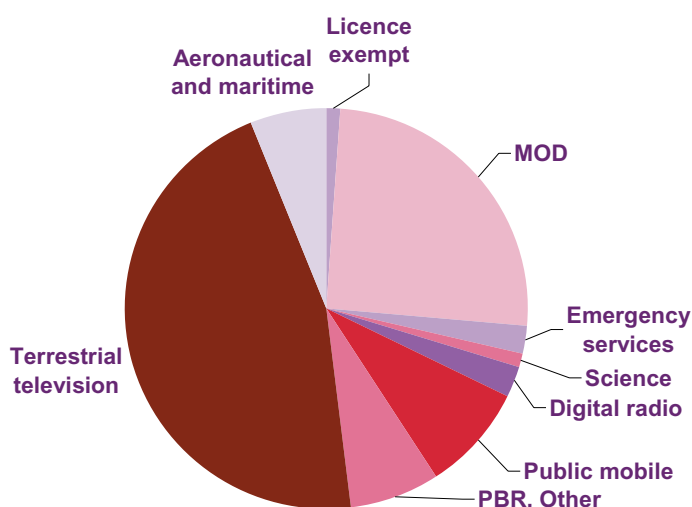
Introduction

- 2.1 Around Europe and around the world, television broadcasting is moving to an all-digital model. There are now a number of digital broadcasting platforms available in the UK: satellite, cable, television over broadband, and digital terrestrial television (DTT).
- 2.2 One of the fundamental inputs used for terrestrial broadcasting is the radio spectrum. Because digital technology is many times more efficient than analogue, digital broadcasting can use the radio spectrum much more effectively than analogue – carrying much more content within a given amount of spectrum.
- 2.3 The move from analogue to digital broadcasting therefore has important consequences for the radio spectrum, which is a scarce resource of great importance to our economy and society.
- 2.4 In the UK, the Government has decided that analogue broadcasting should cease on a region by region basis between 2008 and 2012. This will allow the expansion of digital terrestrial broadcasting to cover as much of the country as analogue broadcasting covers now.
- 2.5 This programme of change - digital switchover (DSO) - will have two major consequences. The first is that there will be an expansion in the number and range of services available via terrestrial television across the whole country. The second is that a large amount of spectrum - the 'digital dividend' – should become available for new uses.
- 2.6 This consultation sets out Ofcom's proposals for the release of the digital dividend. This spectrum, which lies in the frequency range 470-862MHz, is the largest amount of the most useful, lower frequency, spectrum that is likely to be available in the UK for the foreseeable future.

Terrestrial broadcasting in the UK

- 2.7 The spectrum generally regarded as of most value to UK society is that between 200MHz and 1GHz. These frequencies combine characteristics of coverage (propagation) and capacity (bandwidth) which make them suitable for the widest range of applications, including defence, broadcasting, private and public mobile communications, aeronautical and maritime communications and navigation.
- 2.8 Terrestrial television broadcasting is currently much the largest single user of this spectrum, as shown in Figure 2.1. It occupies 368MHz of spectrum in the band 470-862MHz (ultra high frequency – UHF – Bands IV and V), or 46% of the total of the spectrum between 200MHz and 1GHz. This capacity is currently used principally to carry the five main analogue television channels, according to a plan largely dating from 1961. Existing DTT services, and some other secondary uses, fit in and around this analogue plan. Mobile telecommunications, by contrast, uses only about 70MHz, or 9% of the total.

Figure 2.1 Use of 200MHz-1GHz: existing uses



Digital switchover

- 2.9 In September 2005, the Secretary of State for Culture, Media and Sport confirmed that the UK's analogue television signals would be switched off on a region by region basis between 2008 and 2012. Switching off the analogue signal will allow a reorganisation of all 368MHz currently used by terrestrial television broadcasting.
- 2.10 In principle, a wide range of choices might exist about the use of all this capacity². However, important decisions have already been made about the use of most of it. In particular, in 2003, the Government decided that, at DSO, 256MHz (70%) of the spectrum previously used for analogue broadcasting should be assigned to the operators of the six digital multiplexes operating before DSO³.
- 2.11 A major reason for this decision was to allow for the expansion of terrestrial broadcasting, by extending the coverage of digital terrestrial services from the present 73% of population (for all 6 multiplexes) to around 98.5% (for the three Public Service Broadcasting multiplexes) and 90% or more (for the three commercial multiplexes).
- 2.12 So far as viewers are concerned, the effect of assigning 256MHz of this spectrum to DTT will be to increase the number and range of terrestrial channels available to the great bulk of the population. In fact, the benefit to broadcasters and viewers will now be greater than originally planned, as another technical change at DSO (a change in the mode of transmission) will create additional capacity equivalent to about an extra multiplex. As for the operators of the six multiplexes, they will hold rights to large quantities of valuable spectrum at DSO. Their licences will require them to use at least 90% of the capacity for digital television broadcasting.
- 2.13 Much of the spectrum presently used by analogue broadcasting has, therefore, already been spoken for. However, there will still be a substantial amount of

² For example, the analogue services currently available universally could technically be carried on just one digital multiplex, requiring only 40MHz.

³ http://www.digitaltelevision.gov.uk/publications/pub_spectrum_planning.html

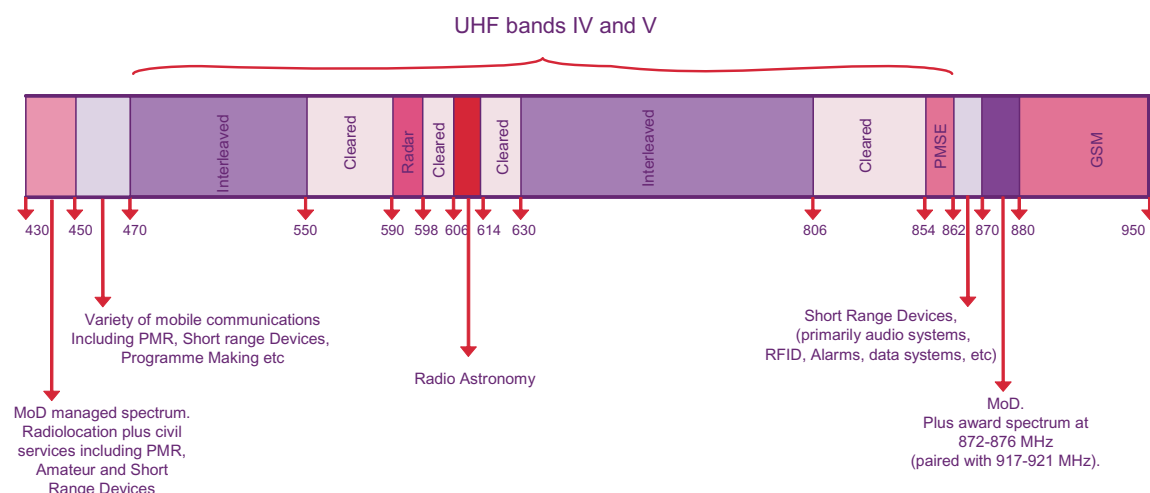
spectrum which will become available for new uses following digital switchover. Digital broadcasting is roughly six times more efficient than analogue, allowing more channels to be carried across less spectrum. The plans for digital switchover will therefore allow an increase in the efficiency with which the spectrum is used - including the potential for a large amount of spectrum to be released for wholly new services. This spectrum is referred to as the 'digital dividend'.

- 2.14 The Government's decision in 2003 provided for this dividend. It stated that at least fourteen frequency channels would be cleared nationwide for reuse in the future, at digital switchover. It also noted that there would be capacity available in frequencies interleaved with the six digital multiplexes which could be used for additional national, regional or local services, and that services such as wireless microphones presently made use of this interleaved spectrum.
- 2.15 These terms – frequency channels, cleared and interleaved spectrum – are explained in more detail below.

The digital dividend

- 2.16 The spectrum that comprises the digital dividend is located between the frequencies 470MHz and 862MHz. This spectrum, and that surrounding it, is in high demand due to its attractive characteristics. At these frequencies, signals generally propagate well – which means that large areas can be covered at relatively low cost, and that signals tend to penetrate buildings easily. At the same time, there is sufficient spectrum available for services that require large capacity or bandwidth.
- 2.17 Figure 2.2 shows the digital dividend in the wider context of the use of spectrum above and below these frequencies. The principal use above 862MHz is GSM mobile telecommunications. Smaller quantities of spectrum are used for short-range licence-exempt applications and by the Ministry of Defence (MOD). Below 470MHz, the principal user is MOD, for a variety of applications including radar. There is also some civil use, including extensive private mobile radio (PMR) use in the 450-470MHz band.
- 2.18 It is worth noting that Ofcom has another spectrum band available for award close to the upper boundary of the digital dividend, though this is much smaller in scale. This is the band 872-876MHz which is paired with 917-921MHz. Further information on this band is available on the Ofcom website.

Figure 2.2 The Digital Dividend Spectrum and Adjacent Users (430-950MHz)



Different types of spectrum

- 2.19 There are several different types of spectrum available for release as part of the digital dividend. The principal distinction that needs to be made is between the 'cleared' spectrum and the 'interleaved' spectrum. These categories are explained below.
- 2.20 **Cleared spectrum** is spectrum that will be available on a UK-wide basis for new uses. Most of this spectrum comprises spectrum that will be cleared as a direct consequence of digital switchover, which will release 14 x 8MHz channels, ie 112MHz. In the existing spectrum plan for these frequencies, these channels are numbered 31-35, 37, 39-40 and 63-68.
- 2.21 Two **other blocks of spectrum** also under consideration in the digital dividend review have the **potential to be cleared**. These are channel 36 and channel 69.
- 2.22 These blocks of spectrum are both currently in use: channel 36 is used for airport radar, and channel 69 principally for wireless microphones. Unlike the other cleared spectrum, they will not be vacated as a direct consequence of digital switchover. But we decided that it would be sensible to review the future use of these channels in the DDR, for several reasons. One was that in both cases a review would be timely, as it might well be feasible to make the spectrum available for new uses. The use of channel 36 for airport radars, for example, has been in decline for some years. Another reason was that there are strong linkages between the future use of these channels and the other spectrum being considered in the DDR – both sets of bands could potentially be used for similar services, so it was important to see the wider picture.
- 2.23 The inclusion of these two blocks means that there is a total of 128MHz under review in the DDR that could potentially be made available as cleared spectrum on a national basis⁴.
- 2.24 The digital dividend also includes the '**interleaved**' capacity that will be available within the 256MHz of spectrum that will be used to carry the six DTT multiplexes.
- 2.25 This interleaved capacity is effectively 'white space' that will exist between transmitters used for multiplex coverage. Similar white space exists at present in analogue broadcasting. The white space arises because, in a multiple frequency network (MFN), any television channel (or multiplex) is carried on a number of different frequency channels around the country. On any given frequency channel used in this way, there will be a geographical zone where use for high-power broadcasting is not possible because of the interference it would cause, but use for low power applications is possible, provided these are carefully designed so as to be compatible with the primary, broadcast use. The white space of this kind that exists in the analogue world will disappear with the end of analogue transmission – but new white space will come into existence in between the expanded digital terrestrial networks.
- 2.26 These three categories of spectrum – the cleared, the potentially cleared, and the interleaved - are hereafter together referred to as the **available UHF spectrum**, or,

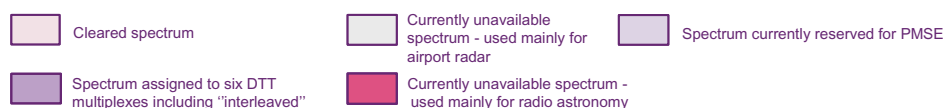
⁴ We have not reviewed the use of channel 38, by contrast, as this spectrum is used for radio astronomy in both the UK and Netherlands, and we do not presently see any prospect of this use ceasing in both countries, which would be necessary to allow significant alternative use in the UK.

more loosely, as the **digital dividend**. The scope of the Digital Dividend Review (DDR) extends to consideration of all of this available UHF spectrum.

2.27 Figure 2.3 below shows these different categories of spectrum in the context of the wider use of UHF between 470 and 862MHz. There are different ways of referring to the spectrum in UHF– it is often referred to by ‘channel number’, each channel representing 8MHz of spectrum. The spectrum can also be referred to using frequencies. For example, channel 21 occupies the frequency range 470-478MHz; channel 36 the range 590-598MHz. For simplicity, this consultation document will generally refer to the spectrum in terms of channel number. Where appropriate, for example in Sections on packaging and auction design, the document may refer to both channels and frequencies.

Figure 2.3 The available UHF spectrum: channel numbers and frequencies

Channel Frequency (MHz)	21	22	23	24	25	26	27	28	29	30	31	32
	470-478	478-486	486-494	494-502	502-510	510-518	518-526	526-534	534-542	542-550	550-558	558-566
	33	34	35	36	37	38	39	40	41	42	43	44
	566-574	574-582	582-590	590-598	598-606	606-614	614-622	622-630	630-638	638-646	646-654	654-662
	45	46	47	48	49	50	51	52	53	54	55	56
	662-670	670-678	678-686	686-694	694-702	702-710	710-718	718-726	726-734	726-742	742-750	750-758
	57	58	59	60	61	62	63	64	65	66	67	68
	758-766	766-774	774-782	782-790	790-798	798-806	806-814	814-822	822-830	830-838	838-846	846-854
	69											
	854-862											



2.28 This figure illustrates that, broadly speaking, the spectrum that could be made available nationally, on a cleared basis, is located in two large blocks:

- channels 31-40, or 550-630MHz (excluding channel 38, 606-614MHz); and
- channels 63-69, or 806-862MHz.

2.29 At the most fundamental level, spectrum is typically a substitutable resource – one channel or block of spectrum will be an alternative for other channels, to a greater or lesser degree depending on basic physical characteristics.

2.30 But it is important to note that, in practice, the differences between frequencies can be greater than this. In particular, additional constraints on use can be created by international agreements and the need to prevent interference with other services within the UK. These constraints can vary significantly between channels. These issues are explored in more detail in Section 3.

Other spectrum bands

2.31 It is important to note that the release of the digital dividend is just part of a wider programme for making spectrum available for new uses.

- 2.32 As part of its spectrum awards programme, Ofcom held two auctions of spectrum during 2006, and has plans to auction a number of other bands over the next couple of years. Figure 2.4 provides more details.
- 2.33 Some of these bands are potential alternatives for some applications that could use the digital dividend. However, the extent to which one band might substitute for another varies by service - and is likely to be affected by many factors, including the business plans of the potential users. In general, lower frequency spectrum, such as UHF, is regarded as more useful and attractive than higher frequencies – though the importance of issues such as interference constraints and international markets for equipment should not be understated.
- 2.34 In addition to releasing available spectrum to the market, Ofcom is also extending the ability to trade to many types of spectrum licence, and seeking to liberalise spectrum by removing restrictions that presently limit its use. This market-based approach to spectrum management is also being extended to spectrum used by public sector organisations such as the MOD, through implementation of the Government's response to the Independent Audit of Spectrum Holdings⁵.
- 2.35 Over several years, the effect of these reforms should be to move spectrum management decisively towards a market-based model, with much greater flexibility over how spectrum can be used, for what and by whom – and a much reduced role for regulation.

Figure 2.4 Forthcoming spectrum awards

872 - 876 MHz / 917 - 921 MHz	Statement and consultation on draft regulations for an award – by the end of 2006/07, possible award in 2007
1452 -1492 MHz (L-Band)	Statement and consultation on draft regulations for an award – in the middle of 2007, possible award in the second half of 2007 subject to international work in the EU's RSC and CEPT
1785 – 1805 MHz (NI)	Statement and consultation on draft regulations for an award published in December 2006, possible award in 2007
1790 - 1798 MHz (GB)	Consultation on the feasibility of an award in 2007/08
2010 - 2025 MHz	Consultation published in December 2006. Possible award by end of 2007
2290 - 2302 MHz	Consultation published in December 2006. Possible award by end of 2007
2302 – 2310 MHz	Consultation on the feasibility of an award in 2007/08

⁵ http://www.spectrumbaudit.org.uk/pdf/spectrum_demand.pdf

2500 - 2690 MHz	Consultation published in December 2006. Possible award by end of 2007 subject to developments at EU level
3.6 – 4.2 GHz	Further work exploring the scope for further terrestrial services to share the band with satellite services
10 GHz, 28 GHz, 32 GHz and 40 GHz	Consultation on draft regulations for an award – by the end of 2006/07, possible awards during 2007/08

2.36 In addition to the programme of spectrum awards above, Ofcom has begun a programme of licensing new national and regional digital radio (DAB) multiplexes⁶. Some of the candidate uses for the available UHF spectrum could be carried on existing or new DAB multiplexes, on which up to 30% of capacity may be used for data services.

Matters covered in this document

2.37 The aim of this document is to describe Ofcom’s proposals for the award of the digital dividend spectrum. This document logically falls into a number of parts:

The following Section (Section 3) provides a summary of various constraints on the use of the available UHF spectrum.

Section 4 sets out the range of potential uses of this spectrum that have been identified to date.

Section 5 provides an overview of Ofcom’s objectives for the Digital Dividend Review, and the approach it has adopted within the review.

Section 6 sets out the strategic options available to Ofcom in the award of this spectrum, and presents Ofcom’s preferred strategic approach for the award.

Section 7 considers issues around a market-led award, including licence-exemption and the mechanism for the award.

Section 8 considers the likely timing of the availability and options for the timing of award of the spectrum considered in the review, including channel 36.

Section 9 sets out the spectrum requirements of the different potential uses of the spectrum and then considers the options available for the packaging of the spectrum.

Section 10 considers the options for auction design.

Section 11 sets out Ofcom’s initial proposals on the non-technical usage rights and obligations to be included in licences for use of the available UHF spectrum.

Section 12 sets out the next steps for the award of this spectrum.

⁶ http://www.ofcom.org.uk/media/news/2006/12/nr_20061201a

Section 3

Constraints

- 3.1 Ofcom's general approach to spectrum is to release it with as few constraints as possible consistent with the need to comply with the UK's international obligations and the need to protect existing services.
- 3.2 The purpose of this Section is to describe, in summary form, the essential constraints that we expect to apply on use of the available UHF spectrum. Further details on the constraints on this spectrum are available in Annex 10.
- 3.3 Those constraints arise from two sources:
 - the UK's international obligations; and
 - the need to protect existing services within the UK that use adjacent frequencies.

International constraints

- 3.4 Some international constraints arise from the UK's obligations as a member of the International Telecommunications Union (ITU), which is an agency of the United Nations.
- 3.5 Radio signals often travel across international borders, so the ITU's rules define a framework for the respective rights and obligations of different countries. A basic principle is that countries should generally have freedom in how they use spectrum, but must not interfere with specific uses in other countries.
- 3.6 Due to the nature of television broadcasting, which uses high power transmission and is therefore more likely to generate signals which travel across international borders, the use of frequencies for television broadcasting is co-ordinated internationally. In relation to analogue television, a fully co-ordinated spectrum plan was agreed for Europe at a conference held by the ITU in Stockholm in 1961. This covered the use of VHF (Bands I and III) and UHF (Bands IV and V), and allowed for the introduction of analogue broadcasting in colour.
- 3.7 A major ITU conference (The Regional Radio Conference - RRC-06) held in Geneva in 2006 agreed a plan allowing for the transition from analogue to digital broadcasting in Europe and other regions. This plan does not require the UK, or any other signatory, to license spectrum for digital television, but it does require the UK to protect uses of spectrum in other countries. Conversely, the UK has rights of protection from uses abroad.

RRC-06 – The Geneva 06 agreement

- 3.8 The Regional Radio Conference 2006 (RRC-06) produced a new Agreement, which has the status of an international treaty (called the Geneva 2006 Agreement – GE-06) and was signed by 101 countries from Europe, Africa, and the Middle East. The Geneva 2006 Agreement comes into force on 17 June 2007 but signatories agreed to apply its terms provisionally from 17 June 2006.
- 3.9 Under the Geneva 2006 Agreement, the UK has been granted the right to assign specific frequencies for digital terrestrial broadcasting, at specific power levels to

stations at particular locations in the UK. These assignments are listed in a document called the Digital Plan (the Plan), which forms part of the Geneva 2006 Agreement. Within the Plan, the UK obtained the rights to operate up to 8 DTT multiplexes within the UHF spectrum. In each area six of these frequencies will be used for the six DTT multiplexes that are already planned to operate after DSO (three PSB multiplexes and three commercial multiplexes). The remaining two are in the cleared spectrum. Neighbouring countries also secured assignments that they are expected to adopt as part of their switchover programmes.

- 3.10 Although the Geneva Agreement and Plan are focussed predominantly on broadcasting services, it is possible to use the Plan entries for uses other than broadcasting. A large number of countries, including the UK and all of its neighbours, signed a declaration formally stating that they may use their digital Plan entries for broadcasting or other terrestrial applications with characteristics that may be different from those appearing in the Plan, on the condition that this different use remains within the envelope of their Plan entries. Furthermore, this declaration provided an agreement that any such use will be afforded protection to the levels defined by the interfering field strengths as arising from their Plan entries, taking into account any relevant bilateral agreements⁷.
- 3.11 However, it is important to note that this declaration does not go so far as to protect all services from harmful interference from other countries. In particular, it does not protect the use of the spectrum for a 'return path' or 'uplink' (the signal travelling from the mobile handset to the base station in mobile communications services). A new international agreement would be needed to give these services protection. Further details are available in Annex 10.
- 3.12 It is also important to note that if the spectrum is used for digital terrestrial broadcasting or another use requiring high-powered transmitters at sites other than those specified in the Plan, then the user must ensure that the field strengths generated in other countries will be no greater than would be produced from assignments in the Plan. If these conditions are met, then these assignments will be protected from international interference by neighbouring countries under the Declaration, to the extent that assignments in the Plan would be protected.
- 3.13 The overall impact of the above provisions is that the UK has the flexibility to use the assignments which lie within the cleared spectrum for any purpose as long as it does not cause more interference, or require more protection, than if it were used strictly in accordance with the Geneva Agreement and Plan.
- 3.14 Although all channels within the available UHF spectrum are very similar, the international obligations to which the UK must adhere mean that different channels will be 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 spectrum channels may be more or less suitable for new services than others.
- 3.15 The Radio Regulations of the ITU also impose constraints on the use of spectrum. These differ in various respects from the detail of the GE-06 Agreement. The two instruments are complementary: the Radio Regulations establish the framework and the GE-06 Agreement defines how that will be used.

⁷ 53 countries signed this declaration. The declaration is available in the Final Acts of the RRC

- 3.16 Any use of the digital dividend spectrum in the UK will have to comply with the international obligations arising from the GE-06 Agreement and the Radio Regulations.
- 3.17 The relevant provisions are discussed in more detail in Annex 10.

The European Union

- 3.18 The European Union also has important powers and responsibilities in relation to management of the radio spectrum.
- 3.19 At the most general level, European law sets out a framework for decisions on matters affecting use of the radio spectrum. This framework derives from the Treaty of Rome, and is set out in detail in directives that were adopted by the European Council in 2002, and transposed into UK law in the Communications Act 2003.
- 3.20 Annex 6 contains a more detailed discussion of this framework. It includes a number of important obligations relating to the regulation of spectrum, such as:
- the requirement to take utmost account of the desirability of making regulations technology neutral;
 - the requirement to promote competition;
 - the requirement to ensure that the allocation and assignment of spectrum is based on objective, transparent, non-discriminatory and proportionate criteria; and
 - the requirement not to make the use of radio frequencies subject to individual licensing, where possible, but to allow for use through a general authorisation.
- 3.21 Ofcom must ensure that the decisions it takes in relation to all use of the radio spectrum, including the digital dividend, comply with European law.
- 3.22 EU institutions also have the power to make binding decisions that can determine many aspects of spectrum usage in the UK. This is described in more detail below.

RSC and RSPG

- 3.23 Under the Radio Spectrum Decision of 2002, the EU has the power to issue Decisions governing the use of spectrum. This can be done in the interests of ensuring effective policy co-ordination and, where appropriate, harmonised conditions for the use of spectrum in the internal market.
- 3.24 These Decisions are binding on EU Member States. Decisions are made by the Radio Spectrum Committee (RSC), which is a committee of spectrum administrations from the 25 Member States. Decisions are made on the basis of proposals made by the European Commission, which therefore has the power of initiative, and can be taken by qualified majority vote if no consensus is reached.
- 3.25 The Radio Spectrum Policy Group is an important European body that exists in parallel with the RSC. Like the RSC, the RSPG's membership is drawn from the relevant administrations in the 25 Member States. However, the RSPG's role is not to make binding Decisions, but to give strategic advice to both the RSC and other EU

institutions on major questions of spectrum policy. It does this by issuing Opinions from time to time. The RSPG is therefore a more strategic body than the RSC.

3.26 No Decision has been adopted by the RSC on matters relating to the digital dividend. However, the RSPG has adopted, or is in the process of adopting, several Opinions that may be relevant to this consultation. None of these Opinions is binding on Member States but they do represent a collective view of spectrum administrations, and can have significant influence on further work within the EU.

3.27 The relevant Opinions are:

- Opinion on the Spectrum Implications of Switchover to Digital Broadcasting, adopted November 2004. This sets out the potential benefits of a co-ordinated approach to digital switchover to enable more efficient and flexible use of the radio spectrum;
- Opinion on WAPECS (Wireless Access Policy for Electronic Communications Services), adopted November 2005. This advocates a more flexible, technology- and application-neutral approach to spectrum management. In general, it supports the approach taken by Ofcom in the Spectrum Framework Review;
- Opinion on Multimedia Services, adopted October 2006. This recommends relaxing constraints on spectrum usage, in line with the principles of WAPECS, so that more spectrum is available that can be used for mobile multimedia services. It refers to UHF as well as to L-Band (1452-1492MHz) and other bands; and
- draft Opinion on the Digital Dividend, issued for public consultation in October 2006. The deadline for comments on this is 15 December and the RSPG is expected to adopt the final Opinion in February 2007. The draft addresses the possibility for some harmonisation action relating specifically to the digital dividend in Europe, points out various difficulties, and calls for a mandate to be given to CEPT⁸ to study the issue.

3.28 All the documents referred to above are available at <http://rspg.groups.eu.int>.

3.29 It is possible that in time proposals may be made for more specific action at European level on the digital dividend, including the possibility of action by the RSC that would be binding on the UK.

Domestic constraints

3.30 It is very important that the overall value of spectrum use is not undermined as a result of new uses of spectrum causing harmful interference to existing users. This means that we need to consider carefully what those existing uses are, and how they might be affected by new uses.

3.31 With the exception of channels 36, 38 and 69, the UHF band between channels 21 and 69 is currently used within the UK for the transmission of analogue and digital terrestrial television services. There is also extensive use on a secondary basis by

⁸ The CEPT is the Conference of European Posts and Telecommunications administrations, one of whose functions is to carry out technical studies in relation to spectrum management. There are 47 member states of the CEPT.

applications such as wireless microphones and in-ear monitors used in programme making, theatres and sports events.

- 3.32 At switchover, the analogue television services will be switched off, and the coverage of the six digital multiplexes will be expanded to cover much more of the UK population. Analogue broadcasting is presently the means by which universal access is provided to the key public service channels free at the point of delivery, but the Communications Act, and subsequent decisions, provide that in future this role should be filled by digital terrestrial broadcasting.
- 3.33 From digital switchover, the three digital multiplexes carrying public service channels will operate from a similar number of sites as used by analogue broadcasting today (at least 1,154). The PSB multiplexes should consequently be available to the vast majority of UK households (98.5%). The three commercial multiplexes have decided to operate from 81 sites serving around 90% of UK households.
- 3.34 The ability of UK viewers to continue receiving these services up to and beyond switchover is an important requirement, especially with regard to the reception of the three multiplexes carrying the public service channels. The following paragraphs explore the potential interference issues that may arise as a result of this expected pattern of usage and the need to protect viewers' reception of these services.

Interleaved spectrum usage

- 3.35 After switchover, the multiplex operators will be operating six DTT networks. These will operate using channels 21 to 30 and 41 to 62 on an interleaved basis. This means that each multiplex will use a variety of frequency channels, with the use of spectrum by one multiplex interleaved with the use of spectrum by other multiplexes. Interleaving occurs both in terms of geography and in terms of frequency – so that, for example, the frequency used by one multiplex at Crystal Palace may be used by another multiplex at Sutton Coldfield and by another multiplex again at Winter Hill.
- 3.36 There are also expected to be a limited number of additional low power DTT stations which will rebroadcast these services to communities not covered by the broadcaster operated stations. These are expected to be licensed to the communities under Ofcom's Digital Self Help Scheme which is currently being consulted upon (see Ofcom's website for further details).
- 3.37 The use of spectrum on an interleaved basis gives rise to a highly complex pattern of frequency usage. However in any one location, of the 32 channels used in total by the DTT multiplexes, only six will be in active use to transmit services to viewers. The other 26 channels are therefore, in principle, available for alternative uses, but the identity of those 26 channels will change from one geographical location to another and the extent to which they can be used will depend heavily on how they are used to carry DTT services elsewhere. It is this 'spare capacity' within channels 21-30 and 41-62 that we refer to in this document as the interleaved spectrum available for award.
- 3.38 The interleaved spectrum is a valuable resource, which can be used for a variety of different services. However, in all cases, the use of these spare interleaved frequencies is severely constrained by the need to protect the reception of the six DTT multiplex services operating on the same and other channels in adjacent localities and regions, and by the need to adhere to the provisions of the GE-06 Agreement and Plan.

- 3.39 As a result, it is likely that the interleaved spectrum will be most suitable for the following types of services:
- **Interleaved broadcast services:** Any new services operating within the interleaved spectrum will have to operate in such a way as to ensure that their signals do not adversely affect viewers' reception of the six DTT multiplexes. There are particular issues about adjacent and image channel⁹ interference, which are discussed in more detail in Annex 10. Interleaved broadcast services could include local or sub-national television using DTT. These services are discussed in more detail in Sections 4, 6 and 9 of this document.
 - **Low power services, such as programme making and special events (PMSE):** These services already operate within the UHF spectrum under a planning regime implemented by JFMG¹⁰ under contract to Ofcom. The main use is for low power radio microphones and in-ear monitoring systems. These services could continue to be operated on an interleaved basis within the retained spectrum, providing that they are subject to restrictions on the operating power of the transmitters and the need for co-ordination of specific assignments to ensure that they do not interfere with the reception of the DTT services in areas adjacent to their location. Other low power services could also make use of this spectrum. These services are discussed in more detail in Sections 4, 6 and 9 of this document.

Cleared spectrum usage

- 3.40 **Channels 36 and 69:** As set out in Section 2, the digital switchover process will result in the clearance of fourteen UHF channels. The DDR is also considering the future use of two additional channels – channel 36 (currently mainly used for radar) and channel 69 (currently used for PMSE services). Channel 38 is mainly used for radio astronomy, and will continue to be used for this purpose for the foreseeable future, and is therefore not included within the DDR.
- 3.41 Channel 36 is managed by the CAA. Ofcom has requested that this channel be vacated and the CAA, having contacted BAE Systems (the only remaining user of the channel), has agreed that the channel can be released and a replacement frequency found elsewhere. However, with a continuing need for air traffic control services, a new radar will be required. This is discussed in more detail in Section 8 (Timing).
- 3.42 The Geneva 06 Agreement contains assignments for radars at a further four sites throughout the UK. While these five radar assignments are internationally recognised and protected, they do not appear in the digital broadcasting plan and hence are not subject to the declaration on flexibility of use described above. Any change of use will therefore need to be agreed with our neighbours.
- 3.43 Whilst no services other than radar, and PMSE in certain areas, are licensed to operate on channel 36 in the UK, it is likely that there will be services operating on these frequencies in neighbouring countries which are expected to be utilising their Geneva 06 assignments. Any new services operating within the UK will have to

⁹ The adjacent channel is the immediate neighbour to any given channel; the image channel in UHF is the frequency nine channels above any given channel

¹⁰ JFMG has been contracted by Ofcom to manage the process of issuing licences to users of radio microphones and related technologies in the UHF and other bands. The current contract runs until 2008.

ensure that they do not exceed the interference limits incorporated in the GE-06 agreement.

- 3.44 Any new services operating within the cleared spectrum will also have to ensure that they provide adequate protection to the six main DTT multiplexes, to radio astronomy (in channel 38) and to other new services also operating within the cleared spectrum. These issues are discussed in more detail below:
- 3.45 **Protection of DTT services:** It is a condition of the licences held by the public service broadcasters that their digital terrestrial services substantially match the current level of analogue coverage, which is calculated to be 98.5% of UK households. It is therefore important that any new services that may operate within the cleared spectrum do not reduce this level of coverage by causing interference to the reception of these services.
- 3.46 This issue is discussed in more detail in Annex 10 which concludes that under some circumstances it is possible that new services operating in the cleared spectrum could cause interference to the reception of DTT services being broadcast within the retained spectrum. The main cause of any such interference is most likely to be adjacent or image channel interference. This can result in a situation where the DTT service may not be able to be received in areas close to a new service's transmitter. This effect is called "hole punching" (meaning that the interfering service can punch a hole in the coverage of the DTT service) and can be caused by the interfering signal having a much higher signal strength at the receiver than the DTT signal. Hole punching is most likely to occur at locations near the edge of the DTT coverage area where the DTT signal strength is relatively low compared with the interfering service's signal strength.
- 3.47 The technical analysis indicated that this interference could be minimised by the adoption of a number of strategies. These strategies are summarised below, and further details are available in Annex 10:
- ensuring that the interfering transmission station was separated by a minimum distance from any DTT receivers;
 - ensuring that the wanted DTT service is re-broadcast from the same location as the new service at a similar operating power; or
 - making use of a guard band of at least one UHF channel to avoid adjacent channel interference. This is obviously not suitable for image channel operation but as the image channel has a greater margin before problems are predicted to occur, this may enable some services to operate satisfactorily.
- 3.48 In general the technical analysis indicated that any one of these techniques would help to enable fixed services being transmitted in adjacent or image channels to DTT services to operate without causing problems. However, it also concluded that the use of mobile handsets transmitting an uplink signal in an adjacent or image channel would have significantly greater difficulty in meeting the interference criteria described in Annex 10. This is because the transmitter causing the interference will be located within the handset and will therefore be mobile. This makes it much harder to take any measure to mitigate against the interference, such as the careful positioning of a transmitter at a suitable distance from any DTT receivers.
- 3.49 Ofcom has recently commissioned ERA to carry out some field trials to evaluate this effect. Further details are contained in Annex 10. The results of these trials suggest

that the actual extent of potential interference to DTT reception caused by mobile uplink services may be less than predicted by a modelling approach.

- 3.50 It is important to note that Ofcom does not consider that the potential interference issue associated with mobile uplink services justifies a prohibition on two-way mobile services (such as mobile communications using cellular technology or broadband wireless services) from using the cleared spectrum. It may also, for example, be feasible to use spectrum within the UHF band for the downlink element of a service, and spectrum in another band for the uplink. More generally, while it is important to be clear about the limits required to avoid harmful interference, it should be a matter for potential users to decide how these limits should be met.
- 3.51 **Protection of other new services using the cleared spectrum:** Given the wide variety of services that may operate within the cleared spectrum it is very difficult to set out specific constraints to protect all the possible types of network configuration. It is therefore proposed that only general requirements will be specified as spectrum conditions or constraints on use beyond those required to protect other existing users as discussed above. These will be concerned with specifying maximum allowable levels of out of channel interference and the need to adhere to the agreed levels of interference specified in the Geneva 06 Agreement.
- 3.52 **Protection of Radio Astronomy Services using channel 38:** Channel 38 is set aside for the use of radio astronomers based at a number of sites around the UK. They use this channel as a quiet band to enable them to pick up very faint radio signals from outside the solar system. Existing broadcast use of the channels adjacent to channel 38 is already heavily constrained by the need to minimise any interference to this use of the channel. Similar restrictions would be required for other uses of these channels (that is channels 37 and 39) for any other services.

Summary & conclusions

- 3.53 Ofcom's general approach to spectrum is to release it with as few constraints as possible consistent with the need to comply with the UK's international obligations and the need to protect existing services. This Section has identified what impact these constraints may have on the use of the available UHF spectrum. The principal points are summarised below, and further detail is available in Annex 10.
- 3.54 Due to the varying nature of neighbouring countries' use of the UHF channels (arising from the pattern of assignments contained within the Geneva 06 Agreement) the extent and locations of incoming interference will vary across different cleared channels.
- 3.55 Due to the complex nature of the planned use of the interleaved spectrum by the six multiplex operators we believe that the spare capacity within these frequencies is most likely to be suitable for use by additional low power DTT services or other low power services such as PMSE. Other potential uses will not be prohibited, but will need to operate within the relevant interference constraints, which may prove difficult.
- 3.56 There is a high risk that any new service operating within the cleared spectrum could cause interference to the reception of DTT services operating within the interleaved spectrum in the same geographical area. This problem (called hole punching) occurs when the new service uses an adjacent or image channel to the DTT service, and when the two services are transmitted from different locations or at different power levels. In order to protect the existing DTT services in line with the commitments on coverage levels provided by the licences, any new services operating within the

cleared spectrum will need to ensure that the level of interference caused by the new service to the reception of the DTT services does not exceed the limits set out in Annex 10.

- 3.57 Technical analysis indicates that the use of mobile devices transmitting an uplink signal within the cleared spectrum may have considerable difficulty in meeting the interference criteria whilst operating at a usable level – though this is not a reason to prohibit such services, which might (for example) use UHF spectrum for the downlink and other spectrum for the uplink. Recent field trials undertaken for Ofcom suggest that the actual extent of potential interference to DTT reception caused by mobile uplink services may be less than predicted.
- 3.58 Any service operating on channels 37 and 39 will have to meet the criteria set out in Annex 10 in order to protect the use of channel 38 for radio astronomy.

Question 2 : Do you have any comments on our analysis of the essential constraints that will apply to the available UHF spectrum?

Question 3 : Do you agree with the more detailed analysis and proposals regarding these technical constraints as set out in Annex 10?

Section 4

Potential uses

- 4.1 The digital dividend could be used for a wide range of different services. The purpose of this Section is to summarise some of the key features of a number of these potential uses that we can currently identify.
- 4.2 However, there is an important caveat that needs to be stressed. This is that there is rapid change in communications technology, and in the services and applications being provided in the communications sector. There is also change in consumer behaviour, as new products come to market and consumer preferences change.
- 4.3 It is highly likely that, as a result of these changes, new technologies will emerge that could make use of the digital dividend. The same is likely to be true of new uses for existing technologies. The timing of this is inherently uncertain: it may happen before DSO is complete; it is more likely over a time horizon of one or two decades.
- 4.4 It is impossible to predict changes of this kind. The analysis which follows is inevitably limited to that which can be known, with more or less certainty, now. But it is important to be aware of the risk that regulation may, as a result, favour potential uses that are well-established or well-known over those that are more uncertain.
- 4.5 The appropriate response to the problem of uncertainty is discussed in Section 6. But it is worth noting that regulation can either create barriers to change – by restricting spectrum to particular uses – or it can facilitate change – by allowing the use of spectrum to change in response to changing circumstances.
- 4.6 The potential uses of the digital dividend that we have identified so far include:
- **mobile television** – and other types of mobile video and multimedia;
 - **digital television** channels aimed at a national market; these could be in
 - **standard definition** (SD) like terrestrial services broadcast now, or in
 - **high definition** (HD);
 - **digital television** channels aimed at a local market – **local television**;
 - **wireless microphones**, and other programme-making and special events (PMSE) applications, like in-ear monitors;
 - **broadband wireless** applications – which could also be mobile;
 - **mobile communications** – services like voice and data;
 - **low power applications** – like hubs to distribute content around the home;
 - services using **satellite** communications; and
 - **public safety services** – like applications for the emergency services.

- 4.7 Each of these services could make use of the cleared spectrum. Most could also operate within the interleaved, though lower power services such as local DTT and PMSE are most suited to the interleaved.
- 4.8 There are also potential applications of individual services that could differ in terms of the target geography or customer group. Two examples of this are discussed below:
- the potential for using this spectrum to enhance rural coverage of mobile broadband services; and
 - the way in which enhanced television services could be provided for viewers with particular accessibility requirements.

Mobile television and video – mobile multimedia

- 4.9 The term ‘mobile multimedia’ covers delivery of a range of services to handheld devices. These could include data, music and services such as mobile TV. There are a variety of technologies which could potentially operate in the UHF spectrum to provide mobile multimedia services, including DVB-H, DMB and MediaFLO.
- 4.10 The UHF spectrum is very suitable for broadcasting mobile multimedia because the signals can travel relatively long distances, and are relatively robust, for example travelling through walls without noticeable degradation. Indeed, mobile multimedia services are being launched at UHF frequencies in a number of countries worldwide, and are well advanced in Italy, Finland and Japan.
- 4.11 However, there are some potential alternatives to UHF spectrum for the provision of mobile multimedia services. Spectrum at L-Band (1452-1492MHz), which Ofcom expects to auction during the second half of 2007, may be suitable for broadcast mobile multimedia services. Spectrum at 2.6GHz, which Ofcom also expects to auction during the second half of 2007, is likely to be suitable for cellular services, which can carry mobile multimedia services. Mobile multimedia services are already being offered over 3G, and via the data capacity available on DAB (Digital Audio Broadcasting - digital radio) multiplexes. However, these alternative spectrum bands are not perfect substitutes for UHF spectrum, due to their different propagation characteristics, which may mean that the options for, and costs of, deployment could vary significantly.
- 4.12 Depending on the coverage and capacity desired, the spectrum requirement for each mobile multimedia operator could be relatively low, perhaps as little as one 8MHz channel, though it could be up to three channels or more per operator. Mobile multimedia operators are likely to prefer the cleared spectrum for these services, though it would be possible for them to operate services with restricted coverage using the interleaved spectrum.
- 4.13 We have found a very high level of interest in using the UHF spectrum for the provision of mobile multimedia services. To date, trials have been conducted in over 17 countries around the world, including in the UK, and potential operators are keen to get access to the digital dividend for this service.
- 4.14 Our research suggests that consumer interest is lower for this service than some others (additional SDTV, HDTV, local TV, mobile broadband). However, there does appear to be willingness to pay for mobile TV services amongst a minority. Ofcom’s research provides estimates that between 10% and 12% of adults are willing to pay £5 per month for a mobile TV package (different take up rates are dependent on the

number of channels offered). For further details see the separate market research report¹¹.

- 4.15 Our modelling work indicates that allowing for a wide variety of different assumptions about how the market for these services might develop over time and the availability of alternative spectrum bands, mobile multimedia is a plausible use of the digital dividend with potentially high value to society.

Digital terrestrial television – Standard Definition

- 4.16 One possible use of either cleared or interleaved spectrum would be for more DTT services, in Standard Definition (SDTV). These would be additional to those services that would already be available on the six DTT multiplexes post DSO. SDTV is currently the main mode of television broadcasting, in contrast to High Definition TV, which is discussed below. New standard definition services could be offered on either a subscription or a free-to-view basis.
- 4.17 The available UHF spectrum is particularly suitable for DTT because it is within the frequency range already used for other DTT signals. Household receivers and aerials are already designed to pick up and decode signals at these frequencies, possibly with some re-tuning or replacement required to ensure satisfactory reception of any additional signal. Households would therefore not necessarily require any new equipment to watch SDTV carried on a new DTT multiplex, once they have a digital receiver (set top box or integrated digital TV) capable of receiving existing digital television services.
- 4.18 However, there are a number of alternative delivery platforms for digital television services, including satellite, cable and broadband.
- 4.19 Using current technology, an additional DTT multiplex carrying SDTV services could offer up to ten new channels to viewers in the area served by the signal. More advanced technical standards are also becoming available, and these could allow the carriage of even more services (up to twice as many), though there is a trade-off between capacity and the need for consumers to invest in new set top boxes.
- 4.20 An additional national multiplex could be implemented using between one and twelve of the fifteen available cleared channels, depending on the coverage to be achieved and the need for further international co-ordination. Further detail on spectrum requirements is available in Section 9 and Annex 10.
- 4.21 DTT is a service familiar to UK consumers already. It is widely understood that DTT offers more channel choice compared with analogue terrestrial broadcasting. In the market research carried out on Ofcom's behalf in 2006, consumers were inclined to place a relatively high importance on increasing the number of channels on the DTT platform, compared to the other services tested. However, the research also suggested that the value to individuals and society of these channels was dependent upon the content which was offered. For further details see the market research report published alongside this consultation.
- 4.22 There was a significant level of interest among some industry stakeholders in the provision of additional standard definition services using the available UHF spectrum. However, interest in further SDTV channels among the current public service

¹¹ <http://www.ofcom.org.uk/consult/condocs/ddr/mktresearch>

broadcasters was muted, these organisations preferring to focus on high definition television, dealt with below.

- 4.23 Our modelling work indicates that allowing for a wide variety of different assumptions about how the market for these services might develop over time, and the availability of alternative spectrum bands, SD DTT is a plausible use of the digital dividend with potentially high value to society.

Digital terrestrial television – High Definition

- 4.24 High Definition Television (HDTV) provides over four times the screen resolution of conventional Standard Definition (SD) television resulting in potentially sharper, more lifelike pictures. To date, most of the HD television sets sold have a relatively large screen size, typically greater than 32". Smaller screen HD-ready sets are starting to become available in the market, but it is likely that the perceived quality difference between HD and SD television when viewed on these smaller sets will be less discernible¹²
- 4.25 As is the case for SD DTT, the UHF spectrum is particularly suitable for HDTV because most households already have equipment and aerials tuned, or capable of being tuned, to these frequencies. However, in contrast to SDTV, decoding HDTV signals would require the purchase of additional equipment because HD DTT is expected to use a different encoding standard (MPEG4) from the one currently in use (MPEG2).
- 4.26 But UHF spectrum is not the only possible delivery method for HDTV; there are a number of alternative delivery platforms for digital television services, including satellite, cable and broadband. Indeed, HD services have already been launched on a commercial basis on the cable and satellite platforms by ntl and BSkyB respectively.
- 4.27 For as long as the majority of households could not decode HDTV signals, it might be necessary to "simulcast" services in both HD and SD. This would likely be the case for PSB services, which are intended to be available to 98.5% of the population after DSO. The benefits of HD services would initially be felt as enhanced viewing quality for viewers with HD equipment, but not necessarily as additional content choice, as the HDTV services would probably be duplicates of existing SD services.
- 4.28 A new national multiplex carrying HDTV would use the same amount of spectrum as a standard definition multiplex but would carry fewer services, because the data requirements of HDTV are higher. It is currently forecast that one multiplex could carry up to three HDTV services using the MPEG4 encoding standard.
- 4.29 Therefore, as set out above for SDTV, an additional national multiplex would probably require between one and 12 of the 15 nationally available cleared channels, depending on the coverage to be achieved. A high coverage HDTV service could

¹² The average television viewing distance in the UK is 2.7m from the screen (BBC, TANTON, N.E. 2004 *Results from a survey on television viewing distance* BBC R&D department, White Paper no 90). At this distance, for SD screen sizes 30" and over, the human eye is able to perceive individual screen pixels resulting in less lifelike pictures (BBC Sept 2004, *Tests of visual acuity to determine the resolution required of a television transmission system*, White paper number 92). For smaller screen sizes, the pixels in UK Standard Definition (PAL) images become less discernible reducing the perceived quality difference between HD and SD. However, more recent research by the public service broadcasters in the context of a trial of HD on the DTT platform suggested viewers perceived a higher value to HD on screens of 28" or less.

therefore use a significant proportion of the available UHF spectrum. Further detail on spectrum requirements is available in Section 9.

- 4.30 HDTV is still a relatively new enhancement to television services in the UK. It is not yet clear how consumer demand will develop. HDTV might remain a luxury or niche product, purchased at a premium by consumers with particular interests such as sports or movies, where the increased picture clarity is seen to have significant value. Alternatively HDTV-ready receivers might become the norm for households replacing their TV sets, potentially at some stage leading to an expectation that certain services, for example the PSB services and certain pay channels such as sport, movies or wildlife, would be available in this mode.
- 4.31 Market research carried out for Ofcom in 2006 indicates that at present, consumers place less importance on the availability of HDTV services than they do on increased choice of channels on the DTT platform. It also suggests that they do not perceive significant broader social value from HDTV services being available on the DTT platform. For further details see the market research report published alongside this consultation.
- 4.32 A report on a digital terrestrial HD consumer trial has recently been published by the BBC, ITV Channel 4 and Five¹³. Participants in the trial were required to already have an HD ready TV set, so the sample inevitably included many 'early technology adopters'. Of course, early technology adopters cannot be considered typical of the population at large, so the findings should be considered with this in mind. There was a largely positive reaction to the HD trial. Triallists reported a picture quality that exceeded expectations, that they 'couldn't bear the thought' of going back to standard definition and that they thought it was important that HD be available on the Freeview platform. Nearly four in ten triallists said they would be willing to pay £1-£5 per month for a HDTV service, with 14% willing to pay more than £5 per month. This research suggests that HDTV is likely to be a much valued proposition, to at least a minority of UK consumers. However the size of this minority is uncertain, as is the extent to which HDTV can be expected to become a valued proposition to the majority of UK consumers.
- 4.33 There is a significant level of interest among some industry stakeholders in using the available UHF spectrum to offer HDTV services. The Public Service Broadcasters have argued that spectrum should be reserved for them to offer the PSB channels in HD on the DTT platform. Their arguments, and Ofcom's response, are set out in Section 6 and in Annex 8.
- 4.34 Our modelling work indicates that allowing for a wide variety of different assumptions about how the market for these services might develop over time and the availability of alternative platforms and spectrum bands, HD DTT is a plausible use of the digital dividend with potentially high value to society.

Digital terrestrial television – local TV

- 4.35 A number of local television services are currently offered in analogue form. There is interest in using the available UHF spectrum to offer local television services in digital form, from existing local television broadcasters as well as potential new entrants.
- 4.36 The available UHF spectrum is particularly suitable for local DTT because most televisions and aerials are already tuned, or capable of being tuned, to the

¹³ Full report available at : http://www.itv.com/uploads/filelibrary/1164105071186_0.35243858541202655.pdf

frequencies likely to be used. However, local TV services can also be delivered over other platforms including satellite, cable and broadband, which are not subject to the problem of scarce capacity to the same extent as terrestrial television.

- 4.37 Local DTT would not need to use spectrum on a national basis. It could be delivered in one of two ways: using capacity on one of the national multiplexes, or on a series of local multiplexes. Using a national multiplex, delivering local TV services would require an agreement with the multiplex operator to remove a certain service in an identified area and replace it with the local service (so-called “add-drop” arrangements).
- 4.38 Alternatively, local TV providers, or a multiplex operator acting on their behalf, could use frequencies within the interleaved spectrum to offer local DTT services. Current indications are that the interleaved spectrum could be employed to provide a patchwork of local multiplexes across the UK. It appears possible that this use could co-exist with the other most likely use of interleaved spectrum which has been identified to date, ie PMSE use by professional organisations such as theatres and broadcast programme makers.
- 4.39 The market research commissioned for Ofcom indicated that consumers would be interested in local TV in principle, but much would depend on the details of the actual service available. Research respondents also thought there could be considerable broader social value in a new forum for local news, views and interests. For further details see the market research report published alongside this consultation.
- 4.40 A number of stakeholders in the voluntary, commercial and public sectors have expressed an interest in using the digital dividend spectrum to deliver digital TV tailored to specific local areas.
- 4.41 Our modelling work indicates that allowing for a wide variety of different assumptions about how the market for these services might develop over time and the availability of alternative platforms and spectrum bands, local TV is a plausible use of the digital dividend with potentially high value to society. Our modelling suggests that these services could be commercially viable for a reasonable proportion of the population, though these services are closer to the margins of viability than some alternative uses of the spectrum.

Programme-making and special events (PMSE)

- 4.42 One of the current uses of the UHF spectrum is for programme-making and special events. JFMG manages assignments, and licenses PMSE use, on Ofcom’s behalf. Various parts of the radio spectrum are made available for this use, including the current interleaved spectrum, and channel 69.
- 4.43 Our modelling of the value to producers and consumers of PMSE use of the spectrum is subject to a particularly high degree of uncertainty because of the approach taken to the licensing of this use in the past (which has not resulted in a market price for this service) and because PMSE is often an intermediate product rather than a final good sold to consumers. Given both of these issues it is likely that our estimate of the producer and consumer value of PMSE use is understated. However, the modelling suggests that PMSE is a plausible use for some of the spectrum, particularly for the future interleaved spectrum.
- 4.44 It is useful to distinguish between two different categories of PMSE use - professional, and community use. These are discussed below.

PMSE – professional use

- 4.45 Programme-makers, commercial theatres and event organisers use spectrum to relay sound and picture data across relatively short distances. This allows, for example, wireless microphones to be used on stage in musical theatre, and at events such as Live 8. Other major uses include in-ear monitoring equipment, and talkback. In all cases, the use tends to be low power, but requires assured quality of service to guard against the risk of interference.
- 4.46 The UHF spectrum is suitable for this use partly because these users have already invested in equipment that is tuned to work at the available UHF frequencies. PMSE use occurs in other parts of the spectrum, and PMSE users have adapted, by replacing or re-tuning equipment, to use new parts of the spectrum that have become available to them in the past. However there are transitional costs associated with any such move, and there is a risk of disruption to users who depend on the equipment.
- 4.47 Demand for spectrum for PMSE use is difficult to forecast, though it is expected to rise with time, particularly for special events, as consumer expectations rise. One spur to demand that is currently foreseeable is the 2012 London Olympics.
- 4.48 PMSE stakeholders have strongly communicated their view to Ofcom that they would prefer to retain access to the UHF spectrum on the current basis.

Programme-making and special events (PMSE) – community use

- 4.49 As well as professional PMSE users of this spectrum, a very large number of smaller organisations use the digital dividend spectrum. Wireless PA systems, using channel 69 or interleaved spectrum, are used in the community, for example for religious services, and in schools, pubs and at local events.
- 4.50 The available UHF spectrum is particularly suitable for this use for the same reason as for professional PMSE use: there is a pre-existing pool of equipment that is tuned to use these frequency bands.
- 4.51 It is difficult to put a total value on this type of PMSE use, but there is certainly broader social value to the communities using it, and hence value to society in supporting these activities.
- 4.52 Ofcom has received a number of representations from community PMSE users, requesting that the current arrangements for access to UHF spectrum are extended to cover the period post-DSO.

Broadband wireless access

- 4.53 The available UHF spectrum could be used to provide wireless access to broadband services. This could encompass additional facilities in public spaces such as cafés or libraries, or new “broadband nodes” in rural areas. Additionally, it could be used to support truly mobile broadband access, from portable and handheld devices.
- 4.54 The available UHF spectrum is useful for wireless broadband access because the signal can travel relatively long distances, so that large areas can be covered at lower cost than using higher frequency bands. Having relatively few, lower-frequency nodes would, however, restrict users’ ability to upload data, in comparison with a wireless network of smaller cells at higher frequencies. However, the costs of a

smaller-cell network could be prohibitive, especially in remote, sparsely-populated areas where broadband access is not easy to deliver via other means. The available UHF spectrum might be one of the more cost-effective means of delivering wireless broadband access in some of these areas.

- 4.55 As discussed in Section 3, it is not yet clear how useful the digital dividend spectrum is for the uplink component of mobile services - that is for transmission from a mobile handset or wireless broadband terminal to a base station receiver. This is because of the need to protect DTT receivers in adjacent spectrum from interference. Use of these frequencies for the downlink should however be feasible, and it may be possible to pair digital dividend spectrum with other frequencies.
- 4.56 Alternative frequency bands are already available for wireless broadband services. Fixed wireless access licensees operate in the 3.4-3.6 GHz and 3.6-4.2 GHz bands. Some regional broadband fixed wireless access licences for the 28 GHz band were awarded in 2000. Ofcom is also planning to award spectrum in the 10GHz, 28GHz, 32GHz and, possibly, 40GHz bands in the near future which might be used for fixed broadband wireless access. Fixed and mobile broadband access services could also be offered using the frequencies at 2.6GHz, which Ofcom aims to award for new uses by the end of 2007. WiFi and mobile WLAN equipment already operates in the 2.4GHz and 5GHz bands on a licence-exempt basis and fixed WLAN equipment may operate in the 5.8 GHz band on a light licensed basis. However, all of these are much higher frequencies than the digital dividend, making coverage more expensive to achieve.
- 4.57 Nationwide provision of broadband wireless access using the digital dividend could require between one and five of the 15 cleared national channels. Whether this access would be fixed or truly mobile would depend on the judgement of the provider, consumer demand at the time, and network build and receiver costs.
- 4.58 Our market research indicated that people felt mobile broadband access would benefit them as consumers to some degree. Respondents also felt that this service could be of significant benefit to businesses. They also considered that there could be relatively high broader social value in the availability of mobile broadband access. For further details see the market research report published alongside this consultation.
- 4.59 Industry stakeholders have expressed interest in the UHF spectrum for wireless broadband services, with the majority of interest being in the provision of mobile broadband. Given the lack of interest in offering fixed broadband services using UHF spectrum, Ofcom has focussed on mobile broadband use within this review. Technologies that could be used to offer these services include WiMax and TD-CDMA.
- 4.60 Our modelling suggests that there is some uncertainty over the commercial viability of this use. However, there is a range of plausible outcomes in which the service would be significantly better than viable. Additionally, in these cases, the value to society generated is sufficient to make this use a plausible high value use of the available spectrum.

Mobile communications

- 4.61 The available UHF spectrum could be used for established or new mobile communications services for both data and voice.

- 4.62 As for wireless broadband, this spectrum is useful for mobile telephony because the signal can travel relatively long distances, so that large areas can be covered at lower cost than using higher frequency bands. As a result, the available UHF spectrum might be one of the more cost-effective means of delivering mobile telephony services in rural areas. Lower frequencies generally penetrate into buildings better than higher frequencies, so available UHF spectrum might also be useful in urban and sub-urban areas for in-building coverage.
- 4.63 There are other spectrum bands due to become available which may be suitable for mobile telephony use. For example, the spectrum due to be auctioned in 2007 at 2.6GHz may be suitable. Spectrum is also already available for mobile telephony at 900MHz, 1800MHz and 2.1GHz. In the Spectrum Framework Review: Implementation Plan (SFRIP)¹⁴ Ofcom considered the issues relating to liberalisation of 900MHz and 1800MHz. Ofcom is planning to issue a further consultation document in relation to the application of trading and liberalisation to the mobile sector, including further consideration of the question of 2G liberalisation. It is likely that such a document will be published in the early part of 2007.
- 4.64 The suitability of UHF spectrum for additional mobile telephony capacity is substantially dependent on the cost of making handsets that can operate at UHF frequencies, as well as the frequencies already used. Unless there is a market expectation that the available UHF frequencies will be used for mobile telephony across a large market, say at least three or four major EU countries, it appears unlikely that operators will see business benefits in securing this spectrum for simple mobile telephony services.
- 4.65 Mobile telephony generally requires spectrum that is “paired”, that is in two channels (of a size varying with the technology used) which are not adjacent to one another, but are sufficiently separated in the spectrum to avoid interference between them. Current indications are that mobile telephony could be deployed using paired channels of which either one or both are in the available UHF spectrum.¹⁵ A mobile telephony service operating at these frequencies would probably require a minimum of two channels of cleared spectrum.
- 4.66 Consumer market research indicates that there is interest in the availability of better coverage in mobile telephony services, and that this provides both value to individuals and additional value to society. Further information is available in the market research report published alongside this consultation.
- 4.67 Industry stakeholders have shown some interest in the available UHF spectrum for mobile telephony services, but this interest is largely dependent on a number of factors, including the harmonisation of this spectrum for mobile telephony use in Europe, the related issue of economies of scale in handsets, potentially significant interference constraints and decisions on the liberalisation of 2G mobile spectrum. It is worth noting in this context that the UHF spectrum is one of the candidates for an identification for International Mobile Telephony (IMT) services at WRC-07.
- 4.68 As discussed in Section 3, it is not yet clear how useful the digital dividend spectrum is for the uplink component of mobile services - that is transmission from a mobile handset or wireless broadband terminal to a base station receiver. This is because of the need to protect DTT receivers in adjacent spectrum from interference. Use of

¹⁴ <http://www.ofcom.org.uk/consult/condocs/sfrip/sfip/sfr-plan.pdf>

¹⁵ There are mobile telephony technologies that use unpaired spectrum such as UMTS TDD and DECT.

these frequencies for the downlink should however be feasible, and it may be possible to pair digital dividend spectrum with other frequencies.

- 4.69 Our modelling suggests that there is some uncertainty over whether there is a positive business case for this use. However, there are a range of plausible outcomes in which the business case is positive and significant. Additionally, in these cases, the value to society generated is significant enough to make this use a plausible high value use of the available spectrum.

Low power applications

- 4.70 The digital dividend spectrum could be suitable for certain types of low power uses, including for example wireless home multimedia networks. Increasingly, households use wireless connectivity based around “home hubs”, to enable them to access various media and PC applications throughout their homes. Other low power uses include radio-frequency identification (RFID) such as is used by shops and logistics firms to track items, and wireless “last-mile” broadband access.
- 4.71 The available UHF spectrum has some characteristics that are suitable for such uses, including the ability of signals at these frequencies to pass through walls. However, this may create interference risks with adjoining households, and raise security or viewer protection issues¹⁶.
- 4.72 Home hubs are currently accommodated in different parts of the spectrum, on a licence-exempt basis. Demand for additional spectrum, and for UHF spectrum in particular, is not currently easy to forecast. Similarly, it is not possible at this stage to estimate how much of the available UHF spectrum might be required to accommodate new demand for this use, though it is likely that several 8MHz channels may be required due to data rate requirements and the re-use pattern that would be necessary in order to prevent nearby households interfering with each other.
- 4.73 The market research discovered some interest in the proposition of wireless home networks, at a similar level of interest to HDTV services. Amongst those who were interested there appears to be a relatively high willingness to pay, with the research estimating that 22% of the UK population would be willing to pay £5 per month for this type of service. For further details see the market research report published alongside this consultation.
- 4.74 Another potential use is RFID, however, additional spectrum has recently been made available for RFID use on a licence-exempt basis in the 865-868MHz band. It may therefore be premature to increase the supply of spectrum further until more experience is available on the use of existing frequencies. Last-mile broadband access has also been mentioned as a potential use of the spectrum during pre-consultation discussions. However, the information available to us suggests that this would need licensed access in order to guarantee quality of service.
- 4.75 Several stakeholders have raised the use of low power devices as a possible use of the available UHF spectrum. One stakeholder proposed that 3 channels of the available UHF spectrum should be set aside as licence-exempt, to allow last-mile broadband services to be offered. There has also been interest from large organisations in the availability of UHF spectrum for wireless home hubs.

¹⁶ The nature of interference between households will depend on the desired level of in-building coverage per household and the power levels at which the signals are transmitted.

- 4.76 Given that information is scarce on low power applications which could plausibly generate high value to society from use of the available UHF spectrum, it has not been possible to complete detailed economic modelling of this use. Our consultants have completed an indicative assessment of whether the incremental consumer value generated by some of the suggested low power uses could plausibly be greater than the opportunity cost of making spectrum available. The result of this assessment is that, based on current information about the nature of potential low power uses, the incremental value to society generated by using UHF spectrum is unlikely to be greater than the opportunity costs of denying access to other potential uses of this spectrum. However, this depends critically on the nature of the low power use, and the extent to which other spectrum bands might be suitable alternatives.

Satellite applications

- 4.77 Ofcom has received expressions of interest in using the available UHF spectrum for satellite applications, in particular digital television broadcasts from a satellite.
- 4.78 The Radio Regulations¹⁷ provide the conditions under which the frequency band 620-790MHz may be used for satellite television broadcasting using analogue technology. However, the conditions applicable to the use of this frequency band for satellite television broadcasting are currently under review and a final decision is expected at the World Radiocommunication Conference (WRC) in 2007.
- 4.79 As for all applications, satellite use would need to be within agreed international interference constraints. These constraints, confirmed at the RRC earlier this year, were agreed on a working assumption of DTT use, although they can accommodate other uses subject to appropriate location, orientation and power constraints. CEPT is currently preparing a common proposal for this item at WRC-07 which would allow the use of this band for digital satellite television broadcasting, whilst protecting reception of terrestrial systems. However, the extensive use of the band for terrestrial broadcasting throughout Europe, and the fact that the internationally identified band only includes 10 MHz of the cleared spectrum, would suggest that the prospects of using the digital dividend for satellite broadcasting are low.
- 4.80 Nationally, satellite use is not subject to licensing in the same way as terrestrial spectrum uses, as satellites are located in space, outside UK jurisdiction.
- 4.81 Under the market-led approach to new spectrum awards, Ofcom would expect that a satellite operator wanting access to spectrum would bid for the terrestrial spectrum rights in the auction. If successful, the satellite operator would have secured the protection required to broadcast to receivers in the UK, but would still be subject to the constraints necessary to protect services to neighbouring countries, which as mentioned above will not be known until at least the World Radiocommunication Conference (WRC) late in 2007. The satellite network would have to be internationally co-ordinated under the relevant ITU provisions.
- 4.82 If these constraints were not compatible with a viable business case for satellite broadcasting it would be possible to review the international agreements. However, this would require a new international agreement, through a World Radiocommunication Conference convened with the necessary authority to achieve this. Ofcom is not currently expecting such a review of the international agreements on the digital dividend spectrum.

¹⁷Radio Regulations footnote RR 5.311

- 4.83 No consumer market research or economic modelling was conducted for this potential use.
- 4.84 We have not considered this use any further in this consultation, because it appears that current international constraints would make it particularly difficult to deploy satellite services in the UHF spectrum.

Public Safety

- 4.85 Some interest has been expressed in using some of the available UHF spectrum to provide video services to the emergency services. These services might be provided using DVB-H technology (which could also be used for mobile multimedia services).
- 4.86 It is also worth noting that significant interest has been expressed by some parties in Europe in using UHF spectrum to provide public protection and disaster relief (PPDR) services, with the aim of making a common band available at EU level for this purpose.¹⁸
- 4.87 As noted for mobile multimedia, the UHF spectrum is suitable for these types of service because the signals can travel relatively long distances, can penetrate buildings and are relatively robust.
- 4.88 No consumer market research or economic modelling was conducted for this potential use.
- 4.89 Given the similarities in spectrum requirements between this potential use and mobile multimedia use, this use is not specifically considered further in this consultation.

Access to services for viewers with particular requirements for accessibility on the DTT platform

- 4.90 Stakeholders representing the interests of consumers with disabilities or visual impairment have called for additional DTT capacity to be made available to provide enhanced services for these groups of consumers. A range of applications could use such capacity, including closed signing, signed versions of the main public service channels, a signed TV channel, a 'speaking EPG', additional audio description or clean audio feeds.
- 4.91 These applications would not use standalone spectrum. They would require capacity on a DTT multiplex. Therefore, insofar as they are relevant to the DDR they could only be considered if a new multiplex were created in the available UHF spectrum. At this point, it is uncertain whether additional DTT capacity will be one of the outcomes of the release of the digital dividend spectrum, so we have not considered these arguments in detail.
- 4.92 Any enhanced services of this kind could alternatively be provided by the existing DTT multiplexes. Given that these multiplexes already exist, and that they are consequently not subject to the same levels of uncertainty as the digital dividend, it may be more relevant to consider the arguments made by stakeholders in this context, rather than within the DDR. Ofcom reviews regularly how best to meet the

¹⁸See for example the Draft RSPG Opinion on EU Spectrum Policy Implications of the Digital Dividend, available at <http://rspg.groups.eu.int>

needs of viewers with particular accessibility requirements, and will consider these issues in that context.

- 4.93 Consequently, no economic modelling or consumer research was conducted for this potential use, and we have not considered this potential use any further within this consultation.

Assessment of value and demand

- 4.94 Our general approach to spectrum is to release it with as few constraints as possible, consistent with the need to avoid interference and meet international obligations. However, to do this we need to assess the level of demand for the spectrum in order to effect an efficient primary award.

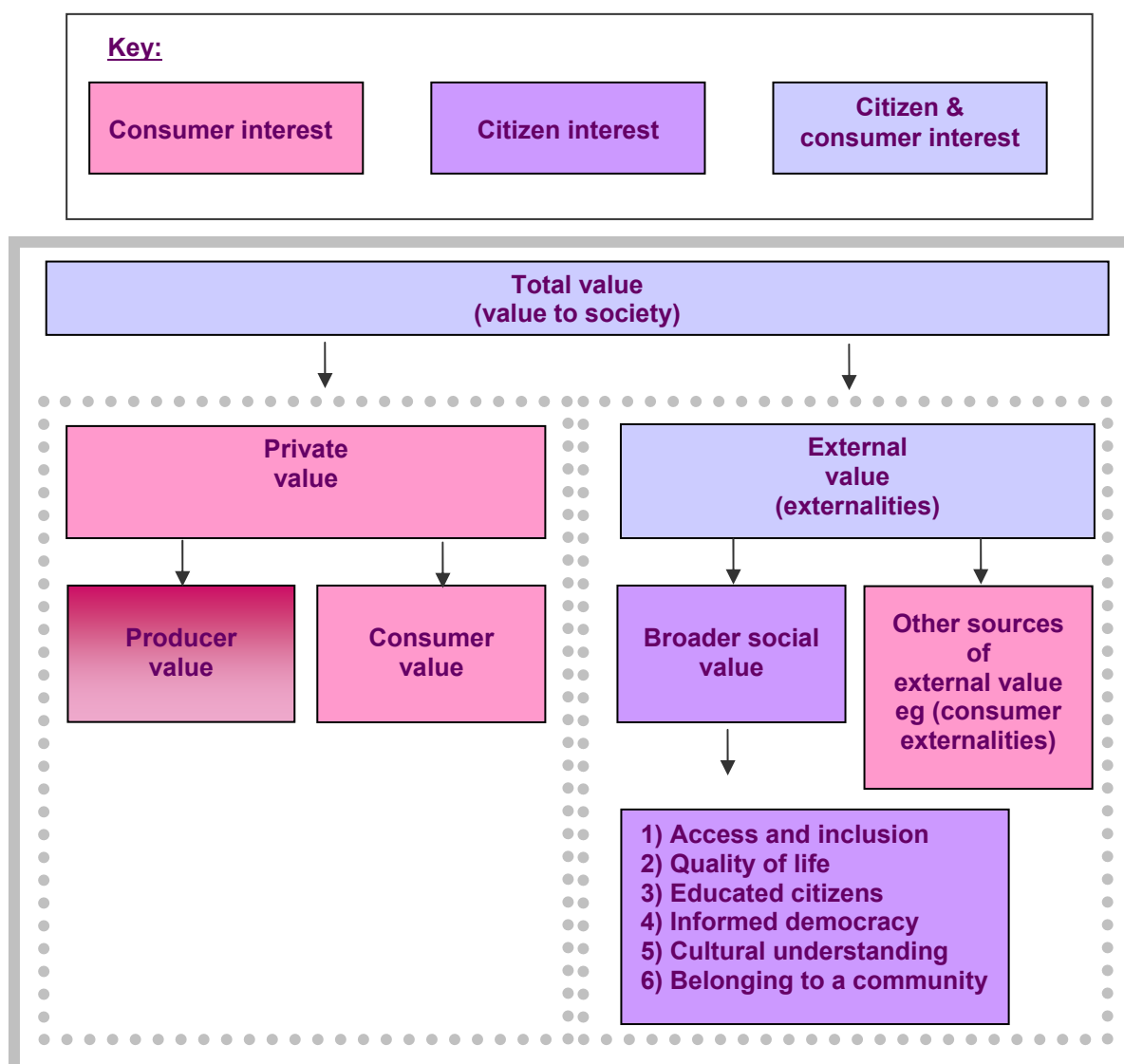
- 4.95 This assessment has considered three sources of evidence:

- industry views;
- consumer market research; and
- economic modelling.

- 4.96 However, before discussing the evidence it is useful to set out the framework we have used to assess the different sources of value to society from the use of spectrum.

Framework for assessing value to society

- 4.97 There are many different ways in which the use of spectrum can contribute value to society. The diagram below shows the framework we have used to identify the different sources of value, and how these contribute to total value, ie value to society. The diagram also shows the relationship between these different sources of value, and the interests of consumers and citizens.

Figure 4.1 framework for assessing value to society¹⁹

- 4.98 The diagram shows that total value to society is made up of private value and external value. Private value includes value that is derived directly by producers and consumers from their activities. This is in contrast to external value which captures spillover effects (commonly referred to as externalities). These externalities include consumer and producer externalities (where the activity of one producer or consumer impacts upon another) and broader social values (where the production or consumption of a product or service generates value to citizens as well as value to producers and consumers)²⁰.
- 4.99 The evidence which is presented below has informed our assessment of these different sources of value in the following ways:

¹⁹ Producer value is relevant to consumer interests as producer value can have a knock-on effect on the provision of services which are of value to consumers, for example, when producer value provides incentives for improvements in service quality or the launch of new innovative services.

²⁰ As discussed in Annex 7 broader social value typically represents citizens' preferences in relation to the provision of goods or services that achieve social goals. Broader social value can be estimated in various ways, such as assessing individuals' willingness to pay (or to trade off alternative services) for services with broader social value.

industry views have informed our assessment of producer value;

- Consumer market research has informed our assessment of consumer value and external value (including broader social value); and

Economic modelling has informed our assessment of producer and consumer value and external value (including broader social value).

4.100 A summary of the findings from these three sources is covered below, with further detail provided in the market research report published on Ofcom’s website, and Annex 9 for the modelling.

Industry views

4.101 Ofcom has held two industry stakeholder events (in February and June 2006), and a consumer / citizen stakeholder event (in July 2006) in relation to the DDR, and has taken these opportunities to gather the views of stakeholders on potential uses of the spectrum. In addition, Ofcom’s consultants have conducted a programme of industry interviews to gather views on a number of issues, including the level of interest in the spectrum for different uses, equipment availability, interference issues and the value to society that each potential service might offer.

4.102 These events and interviews have provided Ofcom with clear evidence that there is a high level of interest in the award of the available UHF spectrum, from a wide range of potential uses and users.

4.103 Figure 4.2 below provides a summary of the views that have been provided to Ofcom by industry (both operators and manufacturers).

Figure 4.2 Summary of industry stakeholder engagement findings for the principal potential uses

Service	Level of Interest	Quantity of spectrum required per operator	Alternative bands or platforms	Comments
Mobile multimedia	High	8-24 MHz	L-Band, 2.6GHz, 3G, DAB, video iPod, MSS at 2GHz	Significant interest, in lower frequencies, especially channel 36
DTT SD	High	8-96 MHz	Satellite / cable / broadband	UHF spectrum is most suitable for terrestrial services
DTT HD	High	8-96 MHz	Satellite / cable / broadband	UHF spectrum is most suitable for terrestrial services
Local TV	High	8-16 MHz (at each location in interleaved)	Broadband / satellite / add/drop	UHF spectrum is most suitable for terrestrial services
Mobile comms	Medium	16-48 MHz	2.6GHz / 900MHz / 1800MHz / 2.1GHz	Interest in spectrum subject to harmonisation of band, handset economies of scale, interference issues and

				decisions on 2G liberalisation
BWA	Medium	8-40 MHz	2.6GHz / 3.4GHz / 3.6GHz / 5GHz / 5.8GHz / 10, 28, 32, 40GHz	Requires contiguous spectrum, UHF frequencies good for coverage
PMSE	High	Interleaved and channel 69	VHF	Significant demand, as users already in this spectrum (equipment tuned for frequencies)
Low power	Medium	8-24 MHz (or perhaps more)	2.4GHz / 5GHz for home hubs.	Main candidate uses identified are last mile broadband or wireless home hubs
Satellite	Low	Not clear	L-Band, MSS at 2GHz	Satellite digital TV
Public safety	Low	8 MHz or interleaved	TETRA?	Video services to emergency services on DVB-H
DTT viewers with particular requirements	Medium	(DTT multiplex)	Satellite / cable / broadband	Not considered further, as does not require standalone spectrum (requires capacity on a DTT multiplex)

Consumer market research

4.104 The full results of a substantial programme of consumer market research, conducted for Ofcom specifically for the DDR, are included as a separate report to this document²¹. There are inherent difficulties in research carried out for projects of this kind. These include the fact that the services covered may not be equally familiar to consumers; in some cases the services may not yet be widely available; and in others they may not even exist. Moreover, those services which can be researched are only a subset of all the potential uses of the digital dividend over the next couple of decades. Technological change is likely to continue, and with it, the range of potential uses of the spectrum will widen. Consumer opinions and preferences can and do change and caution should be applied when using evidence of today's opinions and preferences to make judgements about the future.

4.105 Nonetheless, it is important that Ofcom's decision-making is informed by an understanding of consumers' and citizens' perspectives that is as full and rich as possible, and we have used a wide range of methodologies to seek to provide a rounded picture of preferences and concerns, including quantitative and qualitative techniques, with 'open' or unconstrained questions, and 'closed' or trade-off questions. Although some clear themes emerge from the research, these techniques did not always generate entirely consistent results, probably reflecting the complexity of the issues and consumers' limited familiarity with some of the services examined.

4.106 The research covered the following services in detail:

²¹ <http://www.ofcom.org.uk/consult/condocs/ddr/mktresearch>

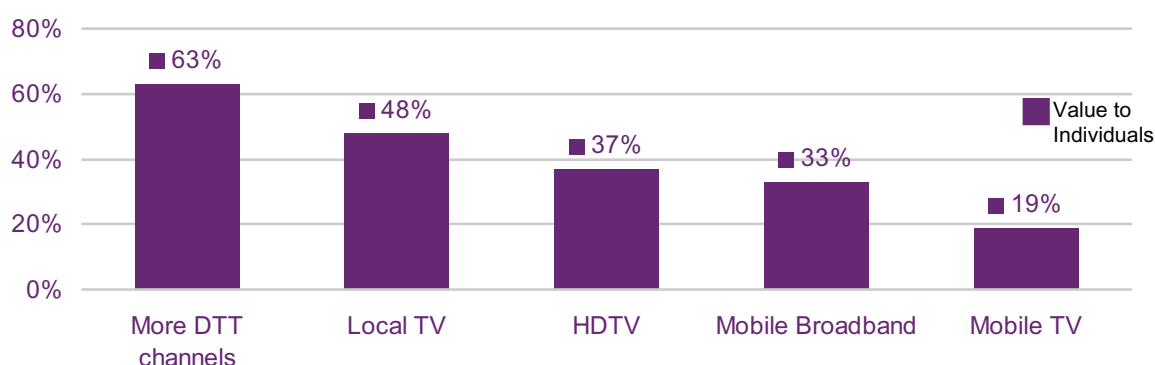
- DTT (standard definition and high definition, and local services);
- mobile multimedia (described as mobile TV); and
- mobile broadband.

4.107 The research also covered cellular mobile services and wireless home hubs (low power devices) in lesser detail than the services above. However, the research did not cover PMSE services or public safety services as these are generally not offered directly to consumers. Nor did it cover satellite services, as this potential use of the available UHF spectrum was not brought to Ofcom’s attention until after the research had been commissioned.

4.108 The research covered attitudes towards the potential uses of the spectrum from two perspectives; personal value to the individual and the broader social value that the services may offer.

4.109 Some key findings relating to the relative perceived importance of availability between the services are set out below.

Figure 4.3 Importance ranking for digital technologies (value to individuals)



QC2alb: Please rank these new services in the order of importance you think they are to the country as a whole/to you individually. Proportion ranking services 1st / 2nd

Base: Total sample representing 89% of population, n = 1500

4.110 Respondents were asked to rank a number of digital services in order of importance to them personally. More DTT channels were considered most important, in line with other findings from the research, followed by local TV. The provision of HDTV and mobile broadband were on a par in terms of importance, with mobile TV deemed to be the least important.

4.111 Additional research suggested that consumers attached a similar level of importance to improving the coverage of mobile communications as they did to more DTT channels and local TV.

4.112 Wireless home networks that would allow devices in the home, such as TV sets and PCs to ‘communicate’ without the need for wires, were also tested in the additional research. The service was rated at a similar level of importance to HDTV services.

4.113 Despite differences in the level of interest between these different services, there was a substantial amount of interest in all of the services included in our research, indicating that all of these services are attractive to consumers.

- 4.114 The qualitative research highlighted that the broader social value of additional DTT channels was closely related to the content of those channels. It was felt that new DTT services were most likely to have the greatest appeal to most of the country, and that they could show programming that would have the most value to society if they were of high quality.
- 4.115 Interest in local TV was also qualified to some extent by concern about the cost-effectiveness and quality of local services. Respondents in this research expressed concern that if services were 'too' local they might not be sufficiently interesting to attract audiences. Conjoint analysis²² suggests that local TV was relatively unimportant in driving consumers' preferences for additional DTT services.

Economic modelling

- 4.116 In collaboration with our consultants we have completed a comprehensive programme of economic modelling for many of the potential uses of the available UHF spectrum.
- 4.117 This modelling has involved the construction of a suite of models which allow the estimation of the value which may be generated by each of the potential uses under a wide range of plausible market outcomes. The models which have been constructed allow estimation of the producer and consumer value²³ which would be generated from the use of the spectrum and of the willingness to pay for spectrum of individual operators.
- 4.118 The services which have been modelled are: mobile multimedia, DTT - SD, DTT -HD, local TV, PMSE (professional and community), mobile broadband, and mobile communications. We have not constructed models for the value of low power uses as at the moment there is insufficient clarity on what these uses might be.
- 4.119 These models have been developed because there is significant uncertainty over how the markets might develop. Amongst the many uncertainties are:
- will HDTV become a widely adopted standard or will it be a more limited product, valued only for specific forms of content?
 - how high will demand for mobile multimedia content be and what will end-users demand from it (live content versus pre-downloaded)?
 - what difference will having local TV over the DTT platform make rather than alternatives, such as delivering it over the internet? and
 - will demand for services such as high-speed mobile broadband and mobile multimedia be limited to urban areas or will demand be sufficient to justify country-wide rollout?
- 4.120 In the face of these uncertainties, amongst many others, we have constructed models which allow estimates of producer and consumer value to be made for a very

²² Conjoint is a technique that derives the relative importance of service attributes based on a carefully crafted series of "Which would you prefer?" type questions, providing a task which is easy for the respondent, and data that are perhaps more reliable than straightforward questioning since the task more closely mimics the thought processes involved in making a purchase decision.

²³ As described in Annex 7, producer value and consumer value together make up private value, but this excludes 'external value' (externalities) which consists of broader social/citizen value plus other sources of external value.

wide range of plausible future “states of the world”. This allows us to consider the range of values that might plausibly be generated in the face of these uncertainties. The high level of uncertainty and the complexity of some of the inter-relationships between services mean that this type of modelling can at best provide an order of magnitude assessment of value. The figures presented below should therefore not be interpreted as precise estimates.

- 4.121 Our methodological approach to the modelling has been to identify the incremental producer and consumer value which is generated by using the available UHF spectrum compared to other alternatives. This is key to the modelling work as for all the potential uses there are a range of alternatives which could be used if UHF spectrum is not available (including using alternative spectrum bands or alternative delivery mechanisms or platforms). The incremental value is the difference between the value generated for producers and consumers with and without the available UHF spectrum. This approach to assessing incremental value is important, and explains why the lower end of the range shown below is in some cases very low, or even zero.
- 4.122 The models which have been constructed allow estimation of the producer and consumer value which could be generated from the use of the digital dividend spectrum, and of the willingness to pay for spectrum of individual operators. The producer and consumer value is the sum of industry producer surplus (profits) and consumer surplus (willingness to pay in excess of the market price).
- 4.123 We have also developed indicative estimates of the external value which could be generated by each of the uses modelled. These estimates are based on the results of our consumer market research.
- 4.124 The assessment of incremental external value should be treated with particular caution. These sources of value are inherently difficult to quantify and there are a number of reasons why these results may be poor indicators of the actual level of external value (for example, some of the services are new and hence it would be difficult for individuals to assess the broader social value of these services; in addition, it can be difficult for individuals to fully appreciate the value a service generates for society). However, taking these difficulties into account, this analysis can help us to assess whether there are significant differences in the relative level of external value generated by the different potential uses of the UHF spectrum.
- 4.125 The range of producer and consumer value generated from the use of the spectrum is reported in Figure 4.4 below, as are the indicative estimates of the ranges of external value associated with these services.
- 4.126 As with Ofcom’s other spectrum awards we have not reported willingness to pay for spectrum as these numbers are subject to uncertainty and could unduly influence the behaviour of potential users of the spectrum and the outcome of the award process. However, we note that willingness to pay for spectrum is likely to be lower than the total of consumer and producer value.
- 4.127 It is therefore important to recognise that none of the numbers quoted in this document can be taken as an indication of auction proceeds.
- 4.128 The figure below sets out for each potential service some of the key variables which have informed our modelling and then presents an estimate of plausible high and low values for the producer and consumer value which could be generated from the use of the spectrum. These high and low values have been identified based on assessing

value for a number of different combinations of the key modelling variables (ie for a wide variety of different plausible future states of the world).

- 4.129 Additionally, the figure includes an estimate of the possible range of spectrum requirements for each of these uses. It can be seen from this that the maximum value that can be realised from use of the spectrum is unlikely to be the total of all the individual maxima – there is simply insufficient UHF spectrum available to meet all these potential sources of demand.
- 4.130 In all cases, we have attempted to estimate the incremental value that can be generated by use of the available UHF spectrum. In relation to external value, our consultants identified that whilst many of the potential uses of the spectrum generated significant external value (including broader social value) *in aggregate*, when the incremental impact of using UHF spectrum to provide each service was considered, the level of external value was found to be significantly lower. It is not possible to provide an indicative estimate of the external value which may be generated from PMSE use as, owing to the nature of this use, it was not possible to include this use within our consumer market research.

Figure 4.4 Producer and consumer value, and spectrum requirements, by service

Service and key variables	Estimated range of producer and consumer value ²⁴	Estimated spectrum requirements (total for this service)	Indicative estimate of external value (as a % of producer and consumer value)
Mobile multimedia: key variables include the coverage levels required, the level of demand, the number of operators in the market, the availability of alternative spectrum, the degree of harmonisation achieved, the network topology deployed	£0.3bn - £3bn	8 – 48 MHz	Up to 10%
DTT - SD: key variables include the number of additional multiplexes, the coverage levels required, pay vs free to view business models, the value to viewers of HD and SD	£0.5bn - £3bn	24 – 112 MHz (using a multi-frequency network) (8 MHz per multiplex would be possible using a single frequency network)	Up to 10%
DTT - HD: key variables include the number of additional multiplexes, the coverage levels required, pay vs free to	£1bn - £3.5bn	24 – 112 MHz (using a multi-frequency	Up to 5%

²⁴ Producer value and consumer value together make up private value, but this excludes 'external value' (externalities) which consists of 'broader social/citizen value plus other sources of external value.

view business models, the value to viewers of HD and SD		network) (8 MHz per multiplex would be possible using a single frequency network)	
Local TV: key variables include the consumer value of local TV, the technical options for delivery over DTT, the options for delivery over other platforms, the number of programming channels offered in each region, the coverage level achieved	£0.1bn - £1bn	8 – 24 MHz (at each location, could use either the cleared or the interleaved spectrum)	Up to 10%
PMSE (professional and community use): key variables include the types of spectrum required (national vs interleaved), the business model used, the level of future demand	£0.1bn - £0.5bn ²⁵	8 MHz of cleared spectrum (preferably channel 69) and up to 32 channels of the interleaved	Not known (this service was not covered by the market research)
Mobile broadband (broadband wireless access): key variables include the level of future demand, the degree of harmonisation achieved, the nature of the coverage required, the number of operators in the market, the availability of substitute spectrum	£0 - £2.5bn	0 – 56 MHz	Up to 15%
Mobile communications: key variables include the level of future demand, the degree of harmonisation achieved, the nature of the coverage required, the number of operators in the market, the availability of substitute spectrum	£0 - £2.5bn	0 – 64 MHz	Up to 15% (value generated by extending coverage in rural areas)

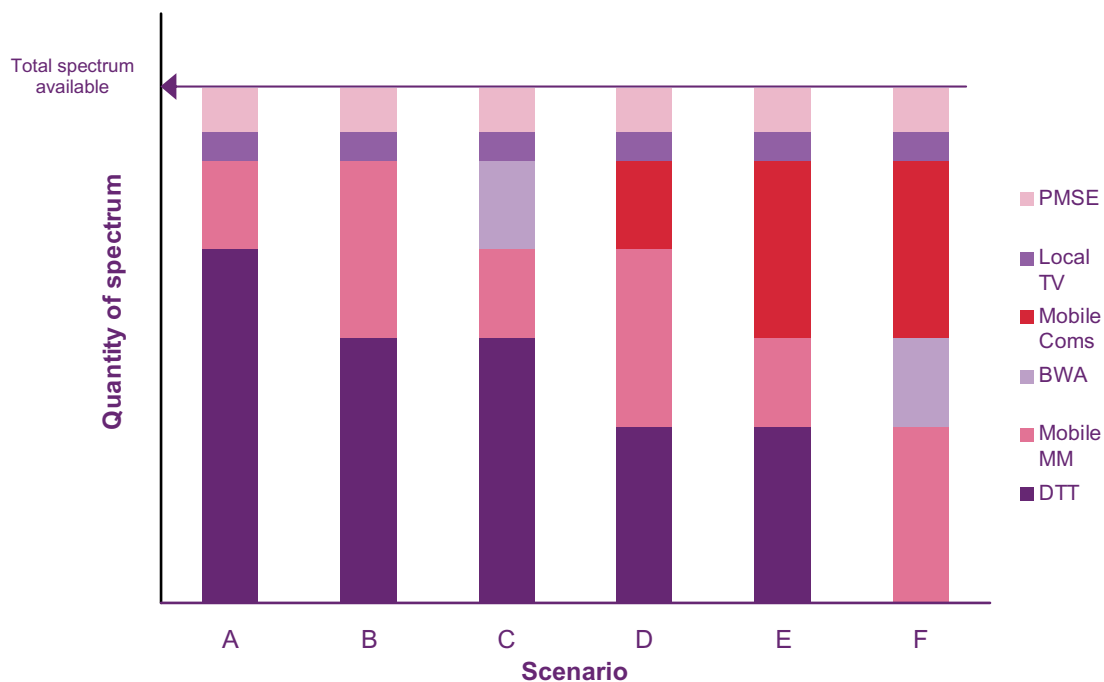
Note: These numbers are not an indication of potential auction proceeds.

4.131 Our assessment therefore shows that there is a great deal of uncertainty over the future value of the use of the available UHF spectrum and the amount of spectrum required by each service. Overall the biggest source of uncertainty lies in the difficulty in predicting the future markets for various services, a number of which are nascent.

²⁵ For the reasons set out above our estimate of the producer and consumer value of PMSE may understate the true value. Therefore, this should be taken into account when interpreting these results.

- 4.132 Our assessment of the external value (including broader social value) also shows that there is uncertainty over the value which may be generated. However, this analysis has shown that the incremental external value which may be generated is relatively small compared to the producer and consumer value and that the level of external value generated may not be significantly different across the various services modelled.
- 4.133 In addition to our estimates of the value of individual services, we have also considered how the aggregate value for producers and consumers from the use of the digital dividend spectrum might vary across a range of plausible combinations of spectrum use.
- 4.134 There is a very wide range of plausible combinations of use of this spectrum. We have not attempted to model all of these as we consider this would be unfeasible and of little benefit. We have, however, examined a range of combinations that we think are plausible in order to understand better the range of likely producer and consumer value.
- 4.135 The figure below shows a number of plausible combinations of spectrum use. For each of the combinations considered, the figure shows approximately how the available UHF spectrum would be split between the different potential uses. Owing to the anticipated excess demand for this spectrum, in all of the combinations some potential uses are unable to gain access to UHF spectrum.

Figure 4.5 Some illustrative combinations of the use of this spectrum



- 4.136 These combinations are illustrative only. However, it is worth noting that all of these combinations have broadly similar aggregate value, with a value to producers and consumers of approximately £5bn-£10bn (net present value over the period 2008-2027 in 2008 pounds). Our analysis of external value suggests that externalities could increase this value by up to 10% in total.

- 4.137 These combinations of use are indicative of a range of different technically feasible outcomes. However, given the significant uncertainty over the value to producers and consumers of spectrum for each of the uses considered, they should not be considered as a representation of the most likely outcomes; nor are they exhaustive.
- 4.138 Whilst the combinations were identified in order to try and take account of the uncertainty over the producer and consumer value which could be generated by individual uses, they only represent point estimates on the continuous scale of possible distributions of spectrum between uses. Hence these combinations do not take account of all possible outcomes for the uses represented, and also do not take into account all of the potential uses of the spectrum. For example, some of the potential uses of the spectrum are not included in this assessment (ie public safety and low power uses), and the assessment does not take account of the potential split of DTT demand between SD and HD.
- 4.139 The combinations set out above cannot therefore be considered to be a prediction of the likely outcome of an award of the UHF spectrum.

Summary

- 4.140 The body of evidence we have collected suggests that there is significant demand for the available UHF spectrum from a wide variety of different uses. However, there is also significant uncertainty over how the different uses may develop over time and the value which each of the uses may generate. The uncertainty which is present is evidenced by the different conclusions which could be reached on the set of potential high value uses if each source of evidence were considered individually. For example, if we based our analysis on the consumer market research we may conclude that the value to consumers of HDTV is relatively low (compared to the value of additional SD channels), whereas if we considered the evidence from the economic modelling (which takes account of how the value to consumers of HDTV may develop over time) we may conclude that the value to consumers and producers of HDTV is comparable in magnitude to the value of additional SD channels.
- 4.141 The conclusions which we can reach from our assessment of the available evidence on the level of demand for UHF spectrum are therefore as follows:
- given the potential levels of demand across the range of services, there is likely to be significant excess demand for the spectrum; and
 - the level of uncertainty which is present indicates that we need to be very careful in drawing conclusions about the relative values to society of different uses.

Question 4 : Do you have any comments on Ofcom's assessment of the potential uses of this spectrum? Are there any potential uses which should be considered that are not mentioned in this document?

Section 5

Objectives and approaches

- 5.1 This section sets out Ofcom's objectives for, and approach to, the Digital Dividend Review.
- 5.2 In setting the objectives for and approach to the DDR, Ofcom has taken account of its statutory duties and has applied them to the particular circumstances of this proposed award. In doing so Ofcom has also taken account of its previous statements on its strategy for spectrum management.
- 5.3 For the reasons set out below, Ofcom believes that the overarching objective of the DDR should be to design a process for the award of the available UHF spectrum which maximises the value of the spectrum to society.
- 5.4 It is not Ofcom's objective to raise revenue by means of spectrum auctions nor, given Ofcom's statutory duties, is this a consideration that Ofcom takes into account.

Ofcom's statutory duties

- 5.5 In addition to Ofcom's principal duty to further the interests of citizens and consumers, Ofcom has a number of statutory duties relevant to the DDR. These may be summarised as a duty to secure "optimal use" of the radio spectrum and secure certain public policy aims in relation to broadcasting and electronic communications services while observing the regulatory principle of intervening as little as possible. Ofcom has a wide measure of discretion in balancing its statutory duties where these conflict. In so doing, Ofcom takes all relevant considerations into account.
- 5.6 A detailed discussion of Ofcom's relevant statutory duties can be found in Annex 6.

Ofcom's strategy for spectrum

- 5.7 In November 2004, Ofcom set out its strategy for spectrum in the Spectrum Framework Review (SFR)²⁶.
- 5.8 Ofcom's vision for spectrum management, as set out in the SFR, is for market forces to play an increasingly important role in determining how spectrum is used. Ofcom believes that this will encourage efficiency in spectrum use, by increasing the likelihood that spectrum will be held by those who can make best use of it, and by creating more freedom for spectrum to be used for more valuable applications.
- 5.9 The historical approach to spectrum management has been one based around 'command and control', where the regulator decides what the uses and users of a particular part of the spectrum should be. Ofcom considers that the management of the radio spectrum today and in future can be carried out more effectively if market forces are harnessed to a significantly greater degree than in the past. Ofcom considers this approach will:
- promote efficient use of the radio spectrum by allowing spectrum to be transferred to and used by the user who values it most highly;

²⁶ <http://www.ofcom.org.uk/consult/condocs/sfr/sfr2/>.

- promote competition by increasing the availability of spectrum for use in the most valuable services; and
 - facilitate economically valuable innovation as new providers enter the market to offer new services.
- 5.10 These characteristics of the market led approach - ie efficiency, promotion of competition, and facilitation of innovation – all tend to bring positive benefits to consumers and citizens, and are therefore highly relevant to Ofcom’s primary duties, as identified below.
- 5.11 Market forces have a role to play both in determining the use of a particular band and in determining who should have the right to use that band.
- 5.12 This approach is primarily implemented through the development and implementation of several policies:
- spectrum trading;
 - spectrum liberalisation;
 - prompt release of unused spectrum into the market allowing maximum flexibility as to subsequent use; and
 - use of spectrum pricing to provide incentives for efficient use of spectrum.

Spectrum trading

- 5.13 Spectrum trading allows the transfer of rights and obligations arising under licences. It therefore allows the market rather than the regulator to determine who uses spectrum. Ofcom considers that spectrum trading will help to optimise the use of the finite spectrum resource for the benefit of UK citizens and consumers.
- 5.14 Ofcom’s general policy in this area was set out in the Trading Statement. Ofcom has published a number of other documents to implement the policy in particular licence classes. See http://www.ofcom.org.uk/consult/condocs/spec_trad/statement/
- 5.15 Section 11 considers whether the licences awarded for the available UHF spectrum should be tradable.

Spectrum liberalisation

- 5.16 Under the command and control approach to spectrum management, the use of a particular piece of spectrum was closely specified, restricting the technology that might be used and the type of service that might be offered. Under the more market-based approach to spectrum management these restrictions are removed so far as possible. The objective of this approach is to let the market determine the most valuable use for a particular band, which may change over time.
- 5.17 In order to allow that to happen it is necessary to liberalise the use of bands. This means removing technology and usage restrictions in licences unless they are necessary for the efficient management of the radio spectrum. Some restrictions might be necessary to comply with international obligations or to ensure that neighbouring users do not suffer an unacceptable level of interference. Restrictions

which would be removed might include provisions which require particular technologies to be deployed.

- 5.18 Ofcom believes that spectrum liberalisation will deliver benefits to UK consumers by allowing the use of spectrum to be changed more quickly to the applications that are most valuable. The introduction of spectrum liberalisation is in line with Ofcom's strategic approach to managing the radio spectrum and complements the introduction of spectrum trading.
- 5.19 Section 11 considers whether the licences awarded for the available UHF spectrum should have any restrictions as to the service or technology that must be deployed.

Releasing spectrum

- 5.20 The third dimension of the new market-based approach to spectrum management relates to the release of spectrum into the market. Historically, under the command and control model, spectrum would typically only be released when the regulator had identified a particular use for it. Under a more market-based approach, there is a presumption in favour of releasing unused spectrum as soon as it becomes available and letting the market find a use. Spectrum trading and liberalisation should enhance the availability of spectrum, as they should allow reallocation of the resource to the most valuable use and user once it is in the market, for example in cases where circumstances change after the initial release of the spectrum.
- 5.21 Ofcom considers this type of approach is preferable as it is more likely to lead to an optimal use of the radio spectrum and to do so more quickly. Accordingly, Ofcom operates with a presumption in favour of releasing spectrum as quickly as possible, consistent with an orderly process.
- 5.22 In general, Ofcom uses auctions as the principal means of assigning spectrum where demand is likely to exceed supply, as this approach allows for the widest possible range of potential uses and users and gives the greatest flexibility to the market to determine the use of spectrum. Markets are, in Ofcom's view, generally superior to administrators in deciding how resources should be used.
- 5.23 Within Ofcom's general approach to spectrum awards, the standard practice is to identify the potential uses of the particular spectrum band to be awarded, and to package the spectrum for auction in such a way as to facilitate an efficient award process, enabling any potential uses and users of the spectrum to bid in the auction.

Maximising value to society

- 5.24 As set out above, Ofcom believes that a market-led approach to the award of spectrum will generally lead to the optimal allocation of spectrum being achieved. However, Ofcom recognises that in designing a spectrum award process it must take account of all of its relevant statutory duties, including its main spectrum duty of securing optimal use of the spectrum.
- 5.25 In the case of digital dividend spectrum, there are a wide number of different potential uses. Some of Ofcom's statutory duties are particularly relevant to some of these uses, but not to others. For example, television broadcasting is one possible use. Ofcom has particular statutory duties that relate specifically to broadcasting, in particular a duty to secure the availability of a wide range of television and radio services of high quality and calculated to appeal to a wide variety of tastes and

interests (see Annex 6 for more details of Ofcom's broadcasting duties). Ofcom also has a duty to secure the wide availability of electronic communications services, which are another possible use of this spectrum.

- 5.26 In designing a process to award the digital dividend spectrum, then, Ofcom must apply all of its relevant statutory duties to the particular facts of this award (in particular the characteristics of the digital dividend spectrum and the most likely uses of the spectrum) and balance those duties where they are in conflict with each other. Ofcom must do so in a way that delivers its principal duty: 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. Ofcom believes that its objective in designing the award process can best be summed up as maximising the value to society of the use of the available UHF spectrum.²⁷
- 5.27 Ofcom recognises that there may be circumstances under which a market-led approach may not maximise the value to society.
- 5.28 Circumstances under which a market-led approach may not prove to be optimal might include:
- where the process of awarding the spectrum (ie through an auction) does not enable high value users to obtain the spectrum – eg if there are very large numbers of small users who have no mechanism for coming together to buy the spectrum as one entity; or
 - where the total value of a service is disproportionately large versus the willingness to pay for spectrum. This might result in one of the higher value uses from a societal perspective obtaining less spectrum in an auction than might have been optimal.
- 5.29 A significant element of the DDR has been to identify any potential areas where a market-led approach to the award of the spectrum may not maximise the value to society. Where any such areas are identified, Ofcom has considered whether intervention is appropriate in order to remedy this potential sub-optimal result. This is discussed in more detail in Section 6, and in Annex 8.
- 5.30 A key reason for this is that the candidate uses of the available spectrum include television broadcasting, for which spectrum policy has historically been used as a method of providing support. Ofcom thinks it is important to consider the issues associated with a transition from this historical model to our wider strategy for spectrum. This is a key focus of the DDR, which is dealt with in more detail in Section 6.

Regulatory impact assessments (RIAs)

- 5.31 Ofcom has a duty under Section 7 of the 2003 Act to carry out RIAs. RIAs 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 and are commonly used by other regulators. This is reflected in Section 7 of the Act, which means that generally Ofcom has to carry out RIAs where its proposals would be likely to have a significant effect on businesses or the general public, or when there is a major change in Ofcom's activities.

²⁷ "Value" in this context includes private value (producer value and consumer value) and external value (broader social/citizen value and other sources of external value). See Annex 7 for further details.

- 5.32 In accordance with Section 7 of the Act, Ofcom has set out an RIA in Annex 5 of this consultation.

Structure of the Digital Dividend Review

- 5.33 In order to determine the optimal award design for the available UHF spectrum, Ofcom has conducted a considerable programme of evidence gathering and analysis. This work programme can be split into five principal areas:
- analysis of technical compatibility;
 - analysis of market conditions and demand;
 - analysis of the value to society of different potential uses of the spectrum and the willingness to pay for spectrum;
 - assessment of any potential arguments for intervention in the market-led process; and
 - spectrum packaging and auction design.
- 5.34 Below is a brief description of the work involved in each of these areas. Further detail of the analysis and conclusions of this work is available in other Sections of this consultation document, and also in the Annexes.

Analysis of technical compatibility

- 5.35 The first task in any spectrum award is to develop a solid understanding of the spectrum. Firstly, Ofcom needs to understand any constraints on the spectrum, arising either through international obligations, or through domestic constraints, such as the avoidance of harmful interference to other services.
- 5.36 Secondly, within the context of the constraints on the spectrum already identified, Ofcom must understand the spectrum requirements of each of the potential services that could use the spectrum, and how the different services will interact with each other (compatibility). Ofcom aims to avoid harmful interference between different uses and users of the spectrum in pursuit of its duty to promote efficient use of the spectrum.

Analysis of market conditions and demand

- 5.37 One of the key elements in the design of any spectrum award is to obtain a detailed understanding of the demand for the spectrum from different potential uses and users. This understanding of demand then informs the packaging process (see below).

Analysis of willingness to pay for spectrum and value to society

- 5.38 This work involves modelling the willingness to pay for spectrum of the different potential uses and users of the available UHF spectrum, and assessing the total value that could be derived from the spectrum for each of the different potential uses. The total value is the value to society, which includes producer and consumer value and external value (which includes broader social value). See section 4 for a discussion of this framework.

5.39 This modelling has several purposes:

- to help Ofcom identify the most likely sources of demand in an auction, in order to ensure that the packaging of the spectrum is suitable for the most likely potential uses of the spectrum;
- to help Ofcom identify whether there are any potential uses of the spectrum for which the willingness to pay for spectrum (WTPS) is not well aligned with the value of the service to society. For example if a particular service had a very low WTPS, but a very high total value, Ofcom might expect that a purely market-led award process might not result in the maximum value to society being achieved – as the high total value use may not obtain any (or sufficient) spectrum; and
- to enable Ofcom to estimate the opportunity cost (in terms of value to society that is forgone) of any potential intervention in the market-led process identified by Ofcom's analysis.

Assessment of any potential arguments for intervention in the market-led process

5.40 A significant element of the DDR has been to identify any potential areas where a market-led approach to the award of the spectrum may not maximise the value to society. Ofcom has assessed potential arguments put forward by stakeholders, and potential arguments identified by Ofcom or its consultants, which suggest that some form of intervention in the market-led process may be required. Where a case for intervention is justified, Ofcom has considered ways of adjusting the market-led approach in order to remedy this potential sub-optimal result, taking into account the opportunity cost of intervention, and also the potential for regulatory failure (ie the probability that a regulatory intervention does not have the outcome that was intended, or has unintended consequences).

Spectrum packaging and auction design

5.41 This work involves taking the outputs of the previous work packages to determine the most likely potential users of the spectrum, and their spectrum requirements, and then packaging the spectrum in such a way as to enable any of those potential uses/users to acquire suitable spectrum for their needs in the award process. In the absence of significant market failures, this approach would be expected to generate the highest value to society from the use of the available spectrum.

5.42 Given the inter-relationships between packaging and auction design, the options for packaging are considered in tandem with options for auction design. Ofcom has also considered the appropriate timing of the auction, and the non-technical conditions that could be included in the licences to be issued for use of the UHF spectrum.

Consultants

5.43 Ofcom commissioned a consortium of consultants, led by Analysys Consulting, in order to assist with the above analysis. The Terms of Reference for the consultancy study can be found at Annex 12. The final consultants' report can be found on the Ofcom website²⁸. This consultants' report is one of many important inputs to Ofcom's analysis and proposals in the DDR.

²⁸ http://www.ofcom.org.uk/consult/condocs/ddr/report_analysys

Section 6

Strategic options

- 6.1 This section identifies the strategic options open to Ofcom for the release of this spectrum. It discusses the merits of these options. It then considers a variety of specific issues that could arise in relation to the potential use of the spectrum for different services.
- 6.2 In light of this discussion, the section concludes by setting out Ofcom's proposals for its strategic approach to the release of this spectrum.

The fundamental choice

- 6.3 The fundamental choice that Ofcom faces in relation to the digital dividend is what level of control we should impose over the future use of this spectrum.
- 6.4 At a strategic level, there is a choice between two broad alternatives:
- Ofcom could choose to impose as few constraints as possible on future use of the spectrum. The minimum constraints would be those necessary to prevent harmful interference to other services in the UK, and to meet the UK's international obligations; and
 - alternatively, Ofcom could choose to impose additional constraints in order to exercise more control over the future use of the spectrum. Constraints of this kind could include restrictions that would limit the use of this spectrum to particular services or technologies or to particular categories of user.
- 6.5 The first approach can be described as **market-led**, as a principal objective would be to leave the users of the spectrum with as much flexibility as possible to determine its use. The second approach can be described as **interventionist** as the reason for imposing additional constraints would be to exercise more control over use of the spectrum, and this control would be given effect through additional intervention.
- 6.6 It is important to note that the question of how the spectrum is released to users - whether, for example, by auction or beauty contest - is secondary to this question of the level of control over future use. We might, for example, be able to choose one of several methods to release the spectrum whatever constraints we had imposed on its future use. But we can only decide on the method of release once we have taken a view on the constraints, as one type of decision can profoundly affect the other – if for example use of the spectrum were to be limited deliberately to some types of service or user, this could have implications for the method of release.
- 6.7 This means that the fundamental question for Ofcom is not how the spectrum should be released, or whether or not it should be auctioned. Rather, the fundamental question is whether it should be Ofcom that decides on the future use of this resource, or whether that decision should be left to the market.
- 6.8 This is not, of course, a binary choice – different approaches could be taken for different parts of the spectrum, and regulation can seek to control or influence the use of spectrum in a number of different ways, which may be more or less constraining. But the existence of intermediate points should not obscure the fact that

there is a strategic choice to be made - between an approach that is essentially market-led and one that is interventionist.

- 6.9 The view we take on this strategic choice is likely to affect not just decisions about the mechanism for releasing the spectrum, but almost every other significant question affecting the digital dividend. These questions include, for example, how the spectrum should be packaged for use, and how we should define the licence conditions for users. In each case a view on whether or not to intervene in the spectrum award process is a pre-requisite for further analysis, as any intervention is likely to influence the choices that are made.

Answering the question

- 6.10 However, making a strategic choice of this kind is not a simple matter. There are other questions that we need to address first before the strategic choice can be made.
- 6.11 We have made clear in Section 5 above that our strategy for spectrum is to make a major shift away from control by the regulator in favour of an approach that as far as possible leaves to the market decisions over who may use spectrum, how, and for what. We have also made clear that our strategy is to release spectrum to the market by auction where supply is likely to exceed demand. This strategy is as relevant to the digital dividend as it is to any other band of spectrum.
- 6.12 It is consistent with that strategy to start with a clear presumption in favour of adopting a market-led approach to the digital dividend, and imposing as few constraints as possible on future use of the spectrum. Starting with this presumption is also consistent with the principles of good regulation, which require us to be transparent and proportionate in our activities, and to ensure that regulation is targeted only at cases where action is needed.
- 6.13 But we need to be clear about the likely consequences of a market-led approach in this case, not least given the variety of potential uses that exist for the digital dividend. The importance of the issue is such that we need to be as confident as possible that the approach we take to this spectrum is likely to generate the most value for society over time.
- 6.14 Taking a market-led approach as the starting position, there are three key questions that need to be addressed in order to identify whether we should vary our approach, by intervening in some form:
- first, how likely is it that a market-led approach to the release of the digital dividend will give rise to some form of 'market failure', and if so how serious would the consequences of this be?
 - second, if there is a risk of market failure, what are the alternative options for responding to the problem? and
 - third, what are the likely costs of these options, what are the risks attached to them, and what is the risk of regulatory failure?
- 6.15 We should only consider imposing constraints on the way the digital dividend can be used if we answer these questions in one particular way, namely:

- we identify that there is likely to be some form of market failure under a market-led approach, and that this has potentially serious consequences;
 - we are clear that the best way of responding to this is to impose constraints on the way spectrum is used – there is no better alternative; and
 - we are clear that the benefits of the intervention clearly outweigh the costs and risks, including the risk of regulatory failure.
- 6.16 If we answer any of these questions differently, we should adhere to the market-led approach for releasing this spectrum, and impose the minimum constraints on its use – though there may be other, non-spectrum interventions that still need to be considered.
- 6.17 This analytical framework for assessing whether or not to depart from the market-led approach to the release of spectrum in response to a risk of market failure is also discussed in Annex 7.

Assessing and responding to market failure

- 6.18 The significance of these questions is that in order to form a view on the case for intervening in some form, it is essential to take a rigorous and consistent approach to the analysis, and in particular:
- to evaluate carefully the reasons why a market-based approach might lead to an inefficient outcome, how likely this is, and how serious the consequences might be;
 - to consider all the options that might exist for responding to a potential problem – intervention via spectrum, for example, is likely to be only one of these; and
 - to consider carefully the costs and risks of any intervention – including the opportunity cost to society if other potential users are denied access to spectrum as a result, and the other effects of intervention.
- 6.19 The paragraphs that follow expand on these points, but it is necessary first of all to define what we mean by ‘market failure’ in this context.
- 6.20 In general, a market failure is said to arise when a market, left to its own devices, fails to deliver the socially optimal use of resources. This might involve too much consumption of a good or service or too little. In the case of school education, for example, reliance solely on a market-based approach is often thought to lead to under-consumption. One reason for this is that families may lack the resources to pay for education at the time it is needed, or may not buy as much as is good for society as whole. The risk of under-consumption is a major reason why in many countries the state provides education free at the point of delivery, and funds this provision from taxation.
- 6.21 Environmental pollution, by contrast, is an activity that will usually be over-provided in a market absent any intervention, as individual polluters do not recognise the full cost to society of the pollution. Governments typically respond to this problem by prohibiting some types of pollution, using regulation, and increasing the cost of other types, through taxation.
- 6.22 In the case of the digital dividend, we consider that there would be a market failure if:

a well-designed auction of rights to spectrum that is subject to only the minimum constraints on use, would not achieve an efficient outcome – that is to say, the holding and exploitation of spectrum by the users and for the uses that generate maximum value for society over time

In essence, this is no different from the other cases mentioned: it is the risk that, under a market-based approach, resources – in this case spectrum – will not be used as efficiently as possible for society as a whole. It is obviously important to ensure that our assessment takes a sufficiently broad view of value to society – including the benefits that we enjoy as citizens as well as consumers.

6.23 There are a number of reasons why market failures can occur. In relation to the digital dividend, we think two major reasons could be relevant²⁹:

- **Transaction costs.** This is the risk that it may be too costly or complex for some types of user to participate in the auction. For example, some types of use involve very large numbers of individual users, each using small amounts of spectrum independently of others. If these users were to take part in the auction, they would need to co-ordinate their demand, or someone would need to do this for them. This could be very costly or complex, making it uneconomic to participate.
- **Existence of externalities.** This is the possibility that some uses or users of spectrum may deliver a high value to society but this may not be fully reflected in the bids made in an auction. For example, some uses or users may be able to create a high value for society but not to earn significant commercial revenues from using the spectrum. This may reduce the amount they can bid in an auction compared to a user who can earn large revenues but may not create so much value for society.

6.24 It is worth noting that the source of the potential problem is very different in these two cases. The first type of problem relates directly to the process of making spectrum available – the problem can therefore be addressed equally directly through changes to that process.

6.25 The second type of potential problem relates to a much wider issue. This is the existence of broader social value (and other externalities) in many aspects of human behaviour. The examples of education and environmental protection have already been mentioned. To these could be added public health, national defence, and scientific research - all of which are activities that can confer high value on society but may be under-provided in a purely market-based world. Cultural activities like museums and public service broadcasting fall into a similar category.

6.26 The existence of broader social value in some activities is a fundamental reason for the existence of Government and of its power to fund those activities through taxation. So the presence of externalities is not an issue that is particular to the digital dividend or to spectrum management, but a much wider issue that is at the heart of public policy.

²⁹ The detailed analysis in Annex 8 also considers other possible sources of market failure, such as imperfections in capital markets and structural differences between markets and concludes that these are unlikely to justify any intervention to deviate from a market-led approach.

- 6.27 This analysis has important implications for Ofcom. It means that we need to consider carefully whether the costs of taking part in an auction could prevent some valuable uses from getting access to spectrum. It also means that we need to look carefully at the risk that some potential uses of the digital dividend could have high value to society but be under-represented in the outcome of an auction.
- 6.28 However, if under-representing the value to society in the outcome of an auction is a risk, it is likely to be just as important to consider *how* to respond to it. For example, one response to this risk could be to constrain the use of spectrum – reserving it for the particular use or user that might be under-represented. Another response might be quite different - not to constrain the use of the spectrum, but to ensure that potential users in this category can access the resources they need to increase their ability to acquire the spectrum in a market-led process.
- 6.29 The choice between mechanisms is likely to have significant implications for the cost and effectiveness of the response – as well, perhaps, as for the transparency and accountability of decision-making.
- 6.30 In the text which follows, we address the mechanisms that policy makers can use to respond to market failures *before* we consider whether or not any particular market failure is likely in the case of the digital dividend.
- 6.31 The reason for considering issues this way round is that there are important general questions about the efficacy of different mechanisms that need to be aired. These are relevant to many possible uses of the spectrum – while any discussion of market failures needs to focus on individual uses and the risk that they will be under-provided under a market-led approach.
- 6.32 In practice, we will need to bring both elements of the analysis together – the likelihood of a market failure, and the options for responding to it – in order to make proposals for what we should do.

Different mechanisms for policy makers

- 6.33 In the discussion that follows, we have not attempted to analyse all possible options that might exist for intervening in response to a risk of market failure, as this would be unnecessarily complex and go beyond the scope of the DDR. Ofcom's responsibility is the management of the radio spectrum, so we have focussed our analysis on the option of intervening by controlling the use of spectrum – that is, using spectrum policy as the instrument.
- 6.34 We have also compared this with an alternative, which is to retain a market-based approach but ensure that potential users have access to the resources that enable them to compete for spectrum. But our discussion of this option cannot be comprehensive as it goes beyond Ofcom's remit. Other mechanisms (such as use of the tax system) might also exist in principle, but these also lie outside Ofcom's remit and have not been explored.

Costs and risks of different mechanisms

- 6.35 To understand why different mechanisms can have different effects it is important to consider a number of issues: the costs and risks of intervention, the effects of uncertainty and the risk of regulatory failure.

- 6.36 It is important to recognise that any policy response to a potential problem of market failure will have costs and risks of its own. These need to be considered alongside the potential benefits of reducing the market failure.
- 6.37 Any intervention will have a cost to society because it will displace resources from one use to another. In the case of spectrum, this can be illustrated simply by recognising that spectrum has many alternative uses and many alternative users. If spectrum is set aside for one particular type of use or user – as has happened in the past – this will impose a cost on society by denying access to that spectrum to other uses or users. This cost is known as an ‘opportunity cost’, because the cost is equal to the value of the opportunity that is being denied.
- 6.38 The same principle applies to all types of intervention. The funding of education through taxation, for example, imposes a cost on society by displacing resources from other possible uses.
- 6.39 It is very important to recognise the existence of opportunity costs in spectrum as these costs can easily be hidden by decisions to ‘allocate’ spectrum to a particular use or user. This can lead to those costs being ignored as they are less evident than the costs imposed by interventions such as taxation – though the costs are just as real.
- 6.40 However, opportunity costs are only one type of adverse effect associated with interventions in markets. There can also be other effects that affect the welfare of society in far-reaching ways.
- 6.41 In particular, there is a fundamental problem with distorting the incentives for efficient use of resources. This is because the use of spectrum involves making choices – spectrum users can choose to use more or less spectrum, and to use it in different ways. It is very important that they have incentives that encourage them to make decisions that lead to the efficient use of resources.
- 6.42 Spectrum users may, for example, be able to economise on the amount of spectrum they use to deliver a given service by investing in more infrastructure or newer technology, such as better coding. Alternatively, they may be able to deliver services in quite different ways. These might use less spectrum, or not involve the use of spectrum at all.
- 6.43 As the time horizon gets longer, the number of choices that are available to users typically expands. This is particularly true in a sector such as communications where there is rapid technological change. Moreover, the extent to which choices exist is itself likely to be influenced by incentives: if users have no incentive to invest in developing alternative options, those alternatives are less likely to exist.
- 6.44 Therefore, interventions that restrict the use of spectrum as a way of correcting for market failure risk seriously distorting the choices made by spectrum users. If users do not face the true opportunity cost associated with the use of spectrum, they will have an incentive to use too much spectrum. This could affect their decision-making in many ways, not all of which can be predicted, but the overall effect is likely to be over-consumption of spectrum by the preferred use or user relative to (a) other inputs and (b) other potential users of the spectrum.
- 6.45 The problem of incentives is one example of the way in which interventions can have profound effects that may not be fully predictable when the intervention is made. This may be because the effects are difficult to predict or because circumstances change.

In other words, interventions can impose ‘dynamic’ costs on society as well as the ‘static’ cost of displacing a given alternative use or user.

6.46 Other examples of dynamic costs include the following in relation to potential interventions in spectrum:

- **Loss of flexibility in the use of spectrum.** If spectrum is set aside for a particular use or user it will typically be necessary to impose conditions requiring the spectrum to be used in that way as it would be inconsistent to do otherwise. But these conditions will seriously constrain the use of the spectrum, and will create a major barrier to changes in how the spectrum is used if circumstances change. In principle, conditions of this kind could be removed or relaxed by a further regulatory decision – but this tends to be a slow and uncertain process. The regulator may even be unable to make some types of change, given the need to treat fairly all those who could have acquired the spectrum at the outset. Change may then be further delayed, or require the regulator to recover the spectrum and re-award it.
- **Adverse effects on competition.** Setting aside spectrum for a particular user or use can also affect the efficiency of competition, potentially making competition less effective at a variety of different levels. Competition between different platforms or networks might for example be affected if the operator of one network or platform gains access to spectrum resources that provide significant cost advantages or benefits in the quality of service that cannot easily be replicated. The significance of these potential effects will obviously depend on the circumstances, but these may be difficult to assess when decisions are made, given the potential for rapid change in the communications sector.
- **Adverse effects on innovation.** Innovation is an unpredictable process, and benefits from innovators being able to experiment at low cost. Experimentation in a commercial setting can be as important as technical research. The opportunities for experimentation will be reduced if spectrum is set aside for a particular use or user, as that spectrum will then be constrained to that use, and the opportunities for learning by trial and error will be reduced. This could affect adversely the supply of innovation.

Uncertainty

6.47 It should be evident from this discussion that a major problem faced by regulators and other policy makers is the difficulty of assessing the effects of intervention. The more difficult this is, and the more uncertainty there is, the greater the risk that the assessment will prove mistaken – and the greater the risk of unintended consequences. Unintended consequences may, on occasion, be beneficial, but in general they are to be avoided, as overall they are more likely to damage the efficient use of resources.

6.48 This is true in relation to assessing the potential benefits of intervention as well as the potential costs. The case for any intervention will depend on taking a view about the future benefits to be derived from a particular use of spectrum. The greater the uncertainty about the future, the greater the uncertainty about those benefits.

6.49 We think that uncertainty points to caution about intervening in spectrum – and we consider that the uncertainty around future uses of the digital dividend is very high.

- 6.50 There are many sources of this uncertainty, and overall these are likely to have a compound effect, making it extremely difficult for a regulator to determine what use of the spectrum is likely to generate the highest value to society. The key sources of uncertainty in relation to the digital dividend are discussed below:
- 6.51 *The wide range of potential uses and users of the spectrum that can be identified.* These were identified in Section 4. The existence of many alternative uses and users in itself creates more uncertainty because it means that there are more potential outcomes in terms of use of the spectrum, and the relative value of those outcomes is more uncertain; and
- 6.52 *The fact that many of these potential applications would be new services to consumers.* For example, there is no commercial experience of high definition channels on terrestrial television, and there is very limited experience of mobile television. There is a great deal of uncertainty about consumers' long-term response to these products, and therefore about the value of these and other products to consumers and to society; and
- 6.53 *The existence of alternatives to the products and services that could be supplied using the digital dividend, and the uncertainty about the likely response of producers and consumers to the existence of these alternatives.* This uncertainty exists at many different levels – for example, it relates to the use of different bands of spectrum for a broadly similar application; it relates to the development of alternative platforms (which may or may not use spectrum) to deliver a particular service; and it relates to the development of consumer preferences in relation to the broader consumption of media, and the extent to which alternative products may substitute for those considered within the DDR. Examples of each of these effects is given below:
- 6.54 *Use of different spectrum bands for a particular service.* Mobile television could be supplied using spectrum in a wide range of different bands, of which the digital dividend is only one. However, each of these bands has different characteristics, eg in terms of propagation, network design, the utility of existing infrastructure, current availability and cost of equipment, quantity of spectrum available, and expected developments in standards, regulation and commercial deployments elsewhere in the world. The various bands are not therefore perfect substitutes for each other. There is significant uncertainty over the degree of substitutability, and therefore over the relative value to society of the digital dividend compared to other bands for this application alone.
- 6.55 *Development of alternative platforms for delivering a particular service.* A service like high definition television could be supplied to consumers using a wide variety of platforms. This includes digital terrestrial broadcasting (which is a potential use of the digital dividend), but also digital cable, digital satellite, and broadband-based platforms, all of which already exist in the UK. It also includes potential new platforms such as planned new free-to-view satellite services. However, the future development of these alternative platforms is uncertain, and is likely to depend on consumer preferences between platforms, which could change over time as service offerings change and as new platforms emerge; the commercial strategies of different platform operators, which cannot readily be predicted; changes in technology, which could affect different platforms' cost and capability differentially; and the development of competition. The uncertainty about the future development of alternative platforms makes it difficult to estimate the value to society of using digital dividend spectrum.

- 6.56 *Consumer preferences in relation to the consumption of media.* A still more fundamental source of uncertainty relates to the potential for change in the way that consumers consume media, and the effects that this could have on the entire sector. Examples of this can be drawn from the uncertainty around products and services that already exist. Developments of the iPod could, for example, prove to be more effective in meeting consumer demand for video content on the move than mobile television; while linear television could be displaced to a greater or lesser extent by the consumption of on-demand content (where the user controls the time of watching, using a broadband connection) and/or content generated by users themselves (as with internet sites such as YouTube and MySpace).
- 6.57 *The high likelihood of further innovation occurring that could affect possible uses of the digital dividend - or indeed the alternatives to those uses.* The discussion so far has sought to concentrate on products and technologies that already exist or can readily be imagined. However, rapid innovation is occurring in the communications sector in general, and in wireless services in particular. There are fundamental causes for much of this, notably the integration of communications and digital computing-based technologies, which have long been subject to high rates of change. The development of the Internet, the spread of broadband, and the migration to digital broadcasting are all manifestations of this. The global nature of the sector is also relevant, as it increases the speed with which innovations pass from one developed economy to another. The significance of this is that it is very likely that new applications will emerge that have an impact on the potential future use of the digital dividend. These may be new products or technologies that could use the spectrum directly, bringing benefits to consumers, or potential substitutes with those services that do use the spectrum, or both.

Regulatory failure

- 6.58 Regulatory failure is in many ways the counterpart of market failure. It is the probability that a regulatory intervention does not have the outcome that was intended, because the benefits are less than expected and/or the costs (static and dynamic) are larger.
- 6.59 The probability of regulatory failure plainly depends on the nature of the intervention being considered and the circumstances faced. But the probability is much greater where there is high uncertainty, for the reasons discussed above.
- 6.60 The risk of regulatory failure also depends heavily on the type of intervention that is made. Some mechanisms for intervention are more prone to causing regulatory failure than others. For example the risk is likely to be greater where:
- the intervention is large and difficult to reverse, and/or difficult to graduate in response to changing circumstances; and
 - less information is available about the costs of intervention.
- 6.61 An intervention that constrains the use of spectrum to a particular use or particular user will tend to score poorly on both these counts:
- it is cumbersome and difficult to adjust, and impossible to graduate step-by-step as new information emerges, for example on alternative uses; and

- it has the effect of *reducing* the information that is available about the costs of intervention – by denying alternative uses and/or users the opportunity to express their demand.

Alternative mechanisms

- 6.62 We have already identified that we do not think that it is within the remit of the DDR to include a comprehensive analysis of the different options that exist for responding to the risk of market failure. Decisions about such options are likely to be a matter for Government rather than Ofcom. However, it is appropriate to include a discussion of some of the issues of principle.
- 6.63 There are many examples of public services whose existence is a response to market failure, and which are funded from public resources. As a general rule, these services are expected to acquire the inputs that they need at market prices. The regime for funding these services recognises this – funding is generally on a transparent and explicit basis, through transfers of money, not of resources in kind like land, labour or machines.
- 6.64 Universities, for example, receive extensive funding from the Government through the various funding and research councils. This funding is intended to be sufficient to enable them to deliver certain goals that would not be delivered by the market such as education and research. The universities are expected to acquire the inputs they need to deliver these outputs by acquiring them in the market. A particular research programme might, for example, require skilled people, land, buildings, equipment (and even spectrum), but it is the university's task to assemble these inputs, and it is funded on the basis of planned output or activity, not via the provision of a series of inputs³⁰.
- 6.65 A similar approach is taken to the funding of many other public services, such as the NHS and local government. Thus, the funding of public services generally recognises the principle that inputs have to be acquired at market prices. There are good reasons why this approach is taken – reasons that are very similar to the points made above about the effects on incentives for efficiency and flexibility.
- 6.66 However, in the past, this approach has not always been taken with the spectrum input. Spectrum, as an input under the control of Government, sometimes has been provided to users at below-market prices as a way of attempting to secure the delivery of particular public services. Public service broadcasting is a good example of this: valuable spectrum has in the past been allocated directly to the PSBs for analogue and digital broadcasting. One effect of imposing these constraints on spectrum use has been to reduce the need for explicit funding of PSB.
- 6.67 For the reasons given above, we do not think that applying a similar approach to the digital dividend is likely to promote the efficient use of spectrum, nor will it maximise the value of the spectrum to society. Whatever the costs and benefits of taking such an approach in the past, the rate of technological change and the proliferation of alternative platforms make it increasingly inappropriate and ineffective in future. The implication of this is that the providers of public services will in future need to acquire spectrum at market prices and through market mechanisms, just as they are expected to acquire other inputs such as land and labour.

³⁰ In some cases public funding may be expressly for capital spending, but the general point still holds. Universities are typically provided with capital, not with resources in kind.

- 6.68 There is however an equally important consequence to this. This is that the financial and institutional regime for providing public services needs to recognise the change. There are many public services that use spectrum as an input. The funding and governance of these services needs to recognise the potential need to acquire spectrum at market prices, as well as the need to manage existing holdings efficiently.
- 6.69 The need to do this was a key theme in the Government's response to the Independent Audit of Spectrum Holdings published in March 2006³¹, and the Government is now engaged in a major programme of change to the management of public sector spectrum, with close support from Ofcom. The scope of the Audit extended to all public sector spectrum use outside broadcasting. Ofcom considers that it will now be important to extend the principles recommended by the Audit, and currently being implemented by Government, to cover all possible uses of the digital dividend including broadcasting.
- 6.70 The aim of this work should be to ensure that the appropriate financial and institutional framework is in place to support potential public sector users of the digital dividend. These users should be able to acquire spectrum at auction, or in the market, if this is the best use of the resources available to them. This work should also extend to consideration of other users who could provide high value to society but who may otherwise be under-represented in the auction outcome (such as the voluntary sector), as similar issues arise.
- 6.71 The design of this framework is something that will need further thought, as is the prior question of the case for additional acquisitions of spectrum by these organisations. But similar questions have been addressed and resolved in relation to other types of input and other public services; they should be soluble in this case too. Ofcom is willing to commit its resources and expertise to assist in this task.
- 6.72 It should be noted that while Ofcom is the independent regulator responsible for most civil use of the radio spectrum in the UK, the Government has reserve powers in relation to spectrum management. In particular, under sections 5 and 156 of the Communications Act 2003, the Government may direct Ofcom in relation to its spectrum management functions. It is, of course, a matter for Government whether to exercise these powers.

Conclusions on mechanisms for intervention

- 6.73 What does this analysis tell us about the different mechanisms for responding to possible market failures in relation to the digital dividend?
- 6.74 In short, the conclusions are that:
- controlling the use of spectrum by imposing extra constraints looks like a poor way of responding to the problem of externalities – which is one reason why some uses of spectrum that may bring a high value to society risk being under-represented in the outcome of an auction;
 - a better response is likely to be to ensure that those uses and users can acquire spectrum at auction or through the market, if this is the best use of the resources available to them. Ofcom is ready to assist with this work; and

³¹ [http://www.spectrumbauidit.org.uk/pdf/spectrum_demand.pdf]

- controlling the use of spectrum may be better as a way of dealing with the problem of transaction costs because this is a problem that arises directly from the process of making spectrum available. But in this case too, careful consideration needs to be given to the costs and risks of intervention, to uncertainty, and the risk of regulatory failure.

6.75 These conclusions provide answers to the important questions identified above. They mean that, even if we do identify a potential market failure that arises from the presence of an externality generated by the broader value to society of a particular service, we should not expect to use spectrum as the instrument for remedying it.

6.76 This points clearly towards taking a market-led approach to the release of spectrum – even if other, non-spectrum interventions still need to be considered.

6.77 Figure 6.1 provides a summary comparison of the reasons for reaching these conclusions.

Figure 6.1 Overview of different approaches to releasing spectrum

	Interventionist	Market-led
Approach	Constraints imposed on how spectrum can be used and/or by whom, to exclude some uses/users.	Minimum constraints on how spectrum can be used - maximum flexibility
Award process	Process limited to permitted uses/users. Depending on constraints, would be auction or beauty contest.	Open award process in which all users can take part. Highest bid wins.
Price of spectrum	Likely to be less than market price. Market price would equal (a) price in market-led process <i>plus</i> (b) option value associated with certainty of availability. Both (a) and (b) would be difficult to determine. More fundamentally, setting price at this level would negate any advantage of intervention, if the purpose of the intervention is to secure the delivery of particular policy goals.	Spectrum provided at market price
Opportunity costs imposed on society	Equal to highest value alternative use/users that are denied the opportunity use the spectrum.	Expressed through the open award process.
Incentive for efficient use of resources	Reduced. Tendency for favoured	Increased. Incentive to consider

	<p>user to over-consume spectrum, and under-consume other inputs. Can have far-reaching effects on efficiency of spectrum use, business strategy, investment decisions, etc.</p>	<p>trade-off between use of spectrum and use of other inputs maximised.</p>
<p>Effects on future flexibility of spectrum use</p>	<p>Reduced.</p> <p>Regulation would restrict use of the band to preferred use/user.</p> <p>Change in regulation would be needed to allow change in use/user. This is likely to be slow and uncertain. Some changes may not be possible if they conflict with legal principles of fairness in relation to initial award process. Change may then be further delayed.</p>	<p>Increased.</p> <p>Maximum flexibility for change in use of spectrum in response to changing circumstances.</p>
<p>Potential effects on competition</p>	<p>Depends on circumstance, but some risk to efficiency of competition between different operators/platforms</p>	<p>In principle, a well-designed auction is likely to be pro-competitive. However, details of design are critical. Need to consider potential behaviour by incumbents, how to encourage entry etc.</p>
<p>Potential effects on innovation</p>	<p>Reduced scope for experimentation at low cost (except for innovation by the preferred use/user).</p> <p>Users/uses other than the preferred use/user are excluded, including potential innovative new uses.</p>	<p>Opportunities for new applications maximised including potential for change in use of spectrum as new uses and users emerge.</p>
<p>Risk of regulatory failure</p>	<p>Likely to be high where;</p> <ul style="list-style-type: none"> - there is high degree of uncertainty - there is a high opportunity cost - intervention is difficult to adjust - intervention reduces information about costs of intervention. 	<p>Low, as regulation minimised</p>

Risk of market failure	Low as use of market is minimised.	<p>Risk that potential uses that are valuable to society but have low commercial value are under-represented in auction outcome.</p> <p>However, this risk can be mitigated by ensuring appropriate financial and institutional framework to support those uses, eg ensure framework allows for possible acquisition of spectrum, while incentivising efficient use of resources.</p>
Transparency of process	<p>Low.</p> <p>Less information available about value of spectrum to society as some uses precluded. Spectrum management used as way of subsidising cost of public policy objectives.</p>	<p>High.</p> <p>Spectrum award process has maximum transparency, and spectrum management is separated clearly from pursuit of public policy objectives (such as public health or culture)</p>

Question 5 : Do you have any comments on our analysis of the choice between a market-led and an interventionist approach to the release of this spectrum? Do you agree with the analysis of different mechanisms for intervening to remedy potential market failures?

Risk of market failure and proposed response

- 6.78 We now turn to our assessment of the likelihood that a market failure will actually occur if we take a market-led approach to releasing this spectrum.
- 6.79 To address this, we have considered a wide range of potential uses for the spectrum. In each case, we have considered the principal arguments we can identify for why reliance on a market-based approach might not lead to the socially optimal allocation of spectrum to uses and users. These arguments have been identified in a variety of different ways. Some have been identified as potential issues through our market research, or market, economic and technical analysis. Many others have been put to us by stakeholders with an interest in particular uses of the spectrum.
- 6.80 Annex 8 sets out the evidence and supporting reasoning underlying this analysis in more detail. This Section should be read in conjunction with that Annex.
- 6.81 The paragraphs that follow set out in summary form our principal conclusions on each of the major types of potential use that we have considered.

PMSE for community use

- 6.82 This category of use comprises some tens of thousands of users of spectrum for wireless microphones and similar equipment such as in-ear monitors. These users may not always require co-ordinated access to spectrum which would guarantee quality of service. A good deal of the use is small-scale and occasional. These users can co-exist independently of each other, and each typically uses a very small amount of spectrum.
- 6.83 At present, this use of spectrum is principally accommodated through access to Channel 69 (854-862MHz), which is widely available for use by PMSE. Each user is required to obtain a licence for use of this band, but evidence from the industry during our research indicates that there is potentially a large amount of unlicensed use in channel 69 and also some likelihood of unlicensed use in channel 70. Community use of radio microphones also occurs in other bands, notably VHF.
- 6.84 Even if spectrum were to be awarded via a well-designed auction, we consider that there would still be a material risk of market failure in this case due to the high transaction costs that would be involved in co-ordinating this large number of small users so that the value of this use could adequately be reflected in an auction.
- 6.85 In order to remedy the risk of market failure in relation to PMSE for community use, we propose that in future channel 69 should continue to be available for use by wireless microphones and similar equipment. However, we believe that it should be appropriate to remove the requirement for licensing, as community users typically do not require their use of the band to be co-ordinated with other users. Indications that there is a significant level of unlicensed use in this channel also imply that co-ordination is typically not required. We therefore believe that it is appropriate to consider licence-exemption of channel 69, for use by PMSE services.
- 6.86 Licence-exemption would mean that users of the channel would no longer need to acquire, or pay for, licences. Ofcom would put in place guidelines which would state the technical parameters of equipment that could operate in the channel. Removing the need for licensing is aligned with Ofcom's objective of light-touch regulation, and should result in fewer administrative time and cost requirements of users of the channel.
- 6.87 However, Ofcom recognises that while the majority of PMSE use of channel 69 is by community users, there is also some use of this channel by users who may require greater levels of co-ordination of use in order to ensure sufficient spectrum quality for their services. Ofcom would welcome views from stakeholders as to:
- whether these users of channel 69 could operate within a licence-exempt model;
 - whether these users could move to alternative spectrum bands (including the UHF interleaved spectrum); or
 - whether Ofcom should consider licence-exemption for only part of channel 69, leaving the remainder available for licensed use at least for a transitional period (and if so, what the split should be).
- 6.88 We have also considered whether, if this approach were adopted, other applications should be allowed to share access to channel 69 with PMSE users. Based on an analysis of the potential for interference between PMSE and other low power devices, we have concluded that the risk of interference between these and PMSE

would be unacceptable and that channel 69 should accordingly be available for low power PMSE devices alone.

- 6.89 Licence-exemption of channel 69 will remove the requirement for users of the channel to obtain licences, saving thousands of users the cost of a licence, and also resulting in a reduction in the amount of time spent by these users in gaining access to the spectrum. This will also result in a reduction in administrative costs for Ofcom.
- 6.90 This approach is preferred to other potential remedies such as auction design and packaging as it would remove directly the potential source of the market failure (high transaction costs arising from the inability of disparate users to aggregate their demand). This approach will have an opportunity cost associated with denying the use of this channel to alternative uses, but we estimate this to be less than for almost all other channels being considered in the DDR. This is because significant constraints exist on the use of these frequencies to protect use by the French Government.
- 6.91 Moreover, alternative use in the UK is likely to be constrained by widespread unauthorised use in the UK (by wireless microphones). This would need to be curtailed for an alternative use to occur, which may not be practical.
- 6.92 It is difficult to assess the value to society of use of this spectrum by wireless microphones and similar equipment, but it is likely to be substantial as use is widespread. Ofcom is committed to working closely with the PMSE community to develop its proposals, and welcomes views from all interested parties.

Question 6 : Do you agree with our proposals to continue making available channel 69 for use by low power PMSE devices? Do you agree with our proposal to make some or all of the spectrum available for use on a licence-exempt basis?

PMSE for professional use

- 6.93 Programme-makers, commercial theatres and event organisers currently use UHF spectrum, and other frequencies, to relay sound and picture data across relatively short distances. This allows, for example, wireless microphones to be used on stage in musical theatre, as well as extensive “backstage” wireless communication in studios, on location and in theatres, and for the high quality production of television, radio and film content.
- 6.94 These users require high quality access, with a guarantee of uninterrupted use of the spectrum. This requires significant co-ordination and planning of use, which cannot be delivered under a licence-exempt model. Existing use of the UHF band is very extensive, particularly for radio microphones, in-ear monitors and talkback links. Access to this spectrum is a key input into many important activities - sporting events of national importance, broadcasting production, and numerous theatrical productions.
- 6.95 The spectrum used at present by professional PMSE users is to a large extent the spare capacity within the interleaved spectrum used by analogue broadcasting. At DSO, the cleared channels will cease to be used by their existing primary use, analogue television, as well as by the secondary use, PMSE. This will reduce the number of channels open for PMSE use. However, the interference environment will change with the move to digital broadcasting, improving the utility of the other channels available for PMSE. In order to understand better the effects of digital

switchover on the PMSE community, we have commissioned a study by Sagentia (formerly Scientific Generics). This study is published alongside this consultation (as well as other related studies by LS telcom and Quotient).

- 6.96 The key conclusions we draw from this work are that:
- there is likely to be sufficient capacity in the interleaved spectrum that will exist after DSO to meet current demand for professional PMSE use;
 - users will, however, need to purchase new equipment or retune existing equipment to be able to make use of the frequencies available in future;
 - there is both the scope for improved efficiency in the use of spectrum by professional PMSE users (particularly at special events) and a need for this given likely increases in demand for this and alternative uses for interleaved capacity (such as local TV); and
 - there is a particular issue in London, where capacity is most constrained. This is discussed later in this Section, and in Section 9.
- 6.97 PMSE use in the digital dividend band is currently licensed on a “command and control” basis, with frequencies made available for this use. There is extensive regulation by Ofcom of the terms on which frequencies can be used; detailed co-ordination and planning is carried out on Ofcom’s behalf by its contractor, JFMG; and the prices paid by users do not reflect the opportunity cost of using the spectrum, but at most recover administrative costs.
- 6.98 The general logic of a market-based approach to spectrum management suggests that in future access by this use to digital dividend spectrum should be on a market basis.
- 6.99 In the long term, we think that moving to a more flexible, market-based approach to the management of spectrum used for PMSE should have many advantages. It will mean that there is less regulation by Ofcom of how the spectrum can be used, and more incentives and opportunities for innovation and better use of the spectrum. It would also mean removing the present regulation that restricts the use of the spectrum to PMSE and instead allowing a much wider range of uses, subject in all cases to meeting stringent technical requirements needed to avoid harmful interference to other services.
- 6.100 However, we recognise that there is a significant risk of disruption to this use over the years up to and during DSO. Professional PMSE use is a well-established existing use of the interleaved spectrum – albeit the use at present is of particular frequencies that may not be available after DSO. We think it is very important not to cause disruption in the short-term to PMSE users. We also note the importance of ensuring that there is sufficient spectrum available for PMSE use during the 2012 Olympics.
- 6.101 We think that some safeguards are therefore needed to ensure a smooth transition into the more flexible, market-based world. Our specific proposals are:
- to ensure that there is uninterrupted access to the existing analogue interleaved spectrum until DSO occurs in each region between 2008 and 2012. This means that in the London region, for example, PMSE users will continue to have access to existing interleaved frequencies until switchover in 2012. The existing contractual arrangements through which Ofcom provides access expire in

September 2008. We will ensure that new arrangements are in place as required from that date; and

- to ensure that there is transitional protection guaranteeing professional PMSE users access to frequencies in the new digital interleaved spectrum until at least the end of 2012.

- 6.102 We would like to work closely with the PMSE user community in designing these arrangements.
- 6.103 Our preferred approach would be to auction a number of packages of digital interleaved spectrum offering a nationwide footprint that would be suitable for use by professional PMSE users. (There would however be no requirement to use digital PMSE equipment in these frequencies.) There would be an obligation on the licensee(s) to make this spectrum available for professional PMSE use until at least the end of 2012 on reasonable terms and conditions.
- 6.104 These packages might be suitable for acquisition by an organisation interested in taking on a role as commercial band manager. This should be feasible given that the number of professional PMSE users is much smaller than the number of community users and some arrangements already exist for the co-ordination of demand. Moreover, value is added to the supply of spectrum through the planning and co-ordination of access. It would also be possible for existing users to work together to support such a bid, or to make a bid themselves. This would be a commercial approach to providing a mechanism for future access, while ensuring transitional protection, at least until 2012.
- 6.105 We recognise, however, that the professional PMSE users are a diverse community. One option therefore might be to see if the award process can be designed so as to encourage one or more bids from organisations representing directly the interests of users and willing to act as a band manager. This approach might put less stress on the commercial motivation for the band manager, but it would be very important to ensure that there remained appropriate incentives for efficiency.
- 6.106 We invite views from interested parties, both on the proposals for transitional protection and the mechanism for providing future access to this spectrum.

Question 7 : Do you agree that there should be transitional protection for professional PMSE users to ensure that they can continue to access interleaved capacity until at least the end of 2012? Do you have any views on the mechanism for providing future access to this spectrum?

Low power applications and innovation

- 6.107 A number of stakeholders have mentioned the potential to use this spectrum for low power uses, such as home wireless networks, radio-frequency identification (RFID) such as used by shops and logistics firms to track items, and wireless “last mile” broadband access.
- 6.108 Low power applications have been a focus of intense innovation in recent years. It is possible that new innovative applications will appear that could make good use of UHF spectrum. However, the potential value to society of low power uses of this spectrum is subject to high uncertainty, arising from uncertainty of demand, which applies to many new uses, but also from the likely rate and direction of future technological change.

- 6.109 To date, the evidence supplied to Ofcom and our consultants has not demonstrated that there would be a high incremental value to society from use of digital dividend spectrum (when compared to alternatives) by one or more of the possible low power uses. However, if such an application or group of applications were to emerge, such that it would be optimal for some of the spectrum to be available for this use, there is a risk of high transaction costs causing market failure if the only means of accessing spectrum is via auction. If low power use did have a high incremental value to society, we think it would probably be better to make spectrum available for this use on a licence-exempt basis.
- 6.110 We propose to defer judgement for now on whether or not to reserve some additional spectrum for low power applications. We plan to gather additional information during the consultation period, with the intention of reaching a decision in time for the Statement. This decision will need to take account of the opportunity cost of making spectrum available on a licence-exempt basis, and the potential for regulatory failures owing to uncertainty over the development of potential future use of this spectrum.

Question.8 : Do you consider that additional spectrum from the digital dividend should be reserved for low power applications? If so, please provide as much evidence as possible about the nature of the application and its potential value to society.

Long-term innovation

- 6.111 Given the uncertainties about developments in technology and consumer demand, a further option might be deliberately to hold some spectrum back for a longer period – perhaps until after DSO is completed in 2012 – to see if innovative applications emerge. This spectrum could be held as a sort of “innovation reserve” against the possibility of unexpected developments. The innovation reserve might prove most useful in catering for new low power technologies, as the problem of transaction costs is likely to be enduring, though it could also be relevant for new high power uses.
- 6.112 However, this approach could have a high opportunity cost to society given that the spectrum could lie vacant for a long period. It is also difficult to see how Ofcom could tell when would be the right time to release any of this spectrum, as innovation is a continuous but unpredictable process. We cannot identify a particular event that we know now is likely to occur in the future that will reduce the uncertainty related to future innovation. If we could, it might make sense to wait for it – but we cannot.
- 6.113 We have therefore put more emphasis on ensuring that the conditions for use of the digital dividend spectrum are as flexible as we can make them. This should put as few barriers as possible in the way of new uses when they emerge – creating the maximum scope for use to change over time. For high power uses, in particular, change should be facilitated by the existence of spectrum trading and imposing minimum constraints on use. However, secondary markets are not likely to be perfect, so there may be a case for more intervention. We would be interested in views on the option of deliberately holding some spectrum back from award.

Question.9 : Do you consider that it would be desirable to hold back some spectrum from award with a view to its potential use for future innovation? If so, please provide comments on how much spectrum should be held back, and for how long.

Local television

- 6.114 There is significant interest from stakeholders in the potential to use the available UHF spectrum to provide access to local content via the DTT platform.
- 6.115 We see two potential issues for policy makers that need consideration in relation to this use and the release of spectrum under the DDR.
- 6.116 The first is that the demand for spectrum is likely to come from different operators in different geographical areas. The potential operators of local television in, say, Manchester are not likely to be the same as in London or Belfast. The release of spectrum on a UK-wide basis therefore risks creating a potential problem of transaction costs – as different and independent local operators would need to co-ordinate their demand in order to participate in the auction.
- 6.117 We think that this problem can be solved relatively easily, by appropriate packaging of the spectrum. Our analysis of the interleaved spectrum suggests that there is a reasonable prospect that local television services could co-exist with professional PMSE use in almost all parts of the country. We also think that these are the most likely uses of the interleaved spectrum – though other uses (such as use for sub-national DTT multiplexes or mobile multimedia) are also possible and should not be discounted.
- 6.118 We therefore propose to offer packages of spectrum that are suitable for local television operation in as many parts of the country as is feasible. These packages are likely to be based on main transmitter sites, such as Winter Hill. This should allow coverage of most metropolitan areas (60-70% of the population), though services may not of course be commercially viable in all areas. Ofcom has already identified over 40 packages which might be made available and could be suitable for local TV use. There may be particular capacity constraints in London; these are discussed in Section 9.
- 6.119 The opportunity costs of taking this approach to packaging the spectrum should be low, as it responds to the most likely demand for the spectrum. Moreover, these packages would not limit the use of the spectrum to local television – it would be possible for other applications to make use of the spectrum, and for use to change over time. No users would therefore be precluded from access to the spectrum.
- 6.120 The alternative to using the interleaved spectrum for local DTT is to use capacity on a national multiplex, using so-called add/drop arrangements. In this approach, a national multiplex operator would agree to ‘drop’ one of the national channels provided on the multiplex and ‘add’ in a local service in its place.
- 6.121 There is nothing in our proposals to rule this approach in or out; local operators who wish to explore this possibility, whether on the existing six multiplexes or any new multiplexes provided using digital dividend spectrum, would be free to negotiate with the multiplex operators on a commercial basis. However, our technical assessment suggests that the costs associated with implementation of add/drop technology would be substantial, particularly with respect to the need to integrate the provision of Service Information. If local authorities or other public bodies wished to consider the case for public intervention to support digital local TV, our guidance would be that the interleaved spectrum is likely to offer a less complex and more cost-effective solution.

- 6.122 The second issue for policy makers is that our assessment of the value to citizens and consumers provides some evidence that broader social value generated by local television may be high compared to the other potential uses of the spectrum. This is reflected in our market research, in which many people identified that local television services could bring additional value to society, going beyond the value to them as individual consumers. This value could come, for example, through additional awareness and participation in local issues and events.
- 6.123 However, the evidence on this point is not unambiguous. Some respondents also commented on the importance of local content not being 'too local', and there was some ambivalence about the extent to which individual viewers would actually want to watch local television services. It is also important to recognise that the market research only captured some dimensions of community – it did not address communities of interest, which can be as important to people as communities of place.
- 6.124 We do however think that local television services could provide significant value to us as citizens – as well as value to consumers. An issue for the DDR is whether we should respond to that possibility by reserving spectrum exclusively for local television – going beyond the packaging approach described above, to preclude the use of spectrum by other users.
- 6.125 We have considered this point carefully, but we do not think the evidence justifies such an intervention, and we do not think that this would be the right way to recognise the potential broader social value of local television.
- 6.126 The fundamental reasons for taking this view relate to the points discussed earlier in this Section, in relation to:
- the need for flexibility in relation to use of the spectrum – we cannot identify that the best use of spectrum, now and in the future, is local television; there are alternative uses of the spectrum;
 - the need for incentives to use spectrum efficiently – giving local television privileged access risks undermining incentives to use spectrum efficiently, and also the incentives to use other platforms such as broadband; and
 - the risk of getting things wrong – there may be social value associated with local television using UHF spectrum, but these may not be what is claimed, and the costs of intervening through spectrum may be higher than expected.
- 6.127 Issues of uncertainty and wider implications are particularly relevant here. There are many alternative options for delivering local content apart from the UHF spectrum - such as broadband and satellite. And there are other potential providers – including the BBC – whose plans are also potentially relevant. In our view, reserving spectrum exclusively for local television would constitute a major new intervention in local media that would require further consideration of these issues and others – such as the effects on local press and radio.
- 6.128 A better approach is to create new opportunities for local television, by offering packages of spectrum that are suitable for this use in as many areas as is feasible, whilst not precluding other uses or users from accessing this spectrum. This will minimise the opportunity cost of the intervention and the risk of regulatory failures, which are potentially significant given the level of uncertainty and the potential wider implications of intervention. If further support is needed to maximise the value to

society of local television, we think this is best provided at local and regional level – through local authorities, Regional Development Agencies, and other public agencies that have a strong presence in the nations (of Scotland, Wales and Northern Ireland) or regions.

Question.10 : Do you agree with our proposal that we should package the interleaved spectrum in a way that would be suitable for use by local television services, but not reserve spectrum solely for this use?

Mobile broadband

6.129 There is some evidence that the value to society of universal coverage of mobile broadband may be high relative to the value to producers and consumers (and that this may become more important in the future). However, for a variety of reasons it is unclear whether the realisation of this value to society is dependent upon the availability of UHF spectrum:

- much of the value to society may derive from the availability of broadband, rather than mobile broadband. Hence, the delivery of these values may not be dependent upon the availability of spectrum at all in much of the country; and
- there is evidence to suggest a strong commercial drive towards making mobile services widely available, potentially using a range of different spectrum bands. There are a number of spectrum bands that can be used for mobile broadband and that will become available in the near future.

Therefore, it is not clear that the risk of this market failure is significant. In addition, it is also not clear whether a spectrum related intervention would be necessary or sufficient to resolve a market failure if it were to occur.

6.130 It is also unclear that any intervention is presently needed to secure wider availability, or that if it is, that this is strongly linked to the digital dividend. As discussed in Section 3, it is not yet clear how useful the digital dividend spectrum is for the uplink component of mobile services - that is transmission from a mobile handset or wireless broadband terminal to a base station receiver. This is because of the need to protect DTT receivers in adjacent spectrum from interference. Use of these frequencies for the downlink should however be feasible, and it may be possible to pair digital dividend spectrum with other frequencies.

6.131 In general, lower frequencies such as UHF are in short supply for services like mobile broadband, and they have particularly attractive features in terms of wide coverage (eg in rural areas) at low cost. In light of this we conclude the DDR should avoid putting unnecessary constraints on use of spectrum for mobile broadband as the value of UHF for this application may be very high relative to higher frequencies because of the properties of UHF spectrum which make it good for extending coverage in rural areas:

6.132 Further to this, any policy intervention to secure wider availability of mobile broadband would raise issues going beyond scope of DDR; it would require consideration of all relevant marginal costs and benefits. It is likely that any such intervention would be much better delivered by relevant public agencies paying for additional coverage (as with initiatives in the fixed broadband market), not via spectrum policy.

Question.11 : Do you agree with our proposal to package the spectrum in a way which does not preclude mobile broadband use, but to take no further action in relation to this use?

National DTT

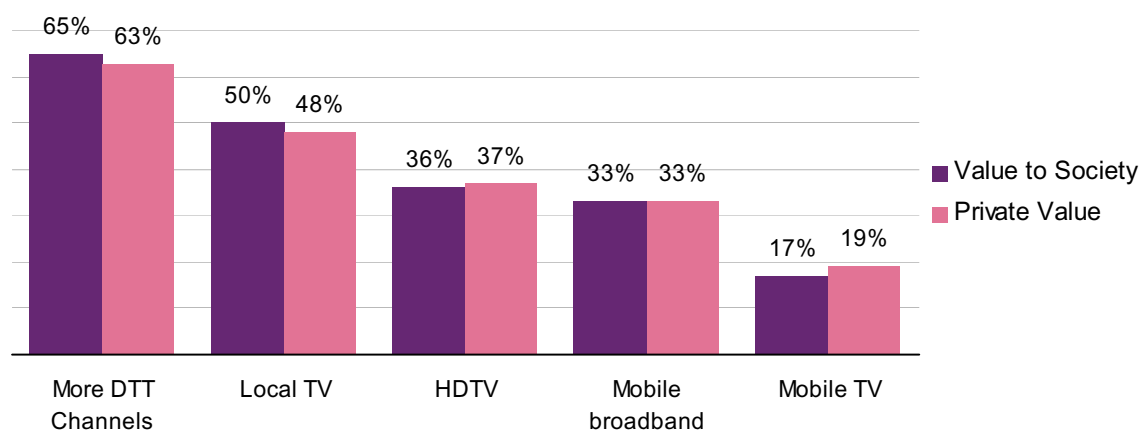
- 6.133 Stakeholders have raised with us a number of reasons why they believe that a market-based approach to this award would not result in an outcome that maximises the value to society, when considering the provision of national DTT services.
- 6.134 Each of these reasons is considered in detail in Annex 8. We deal in this Section with only one of the many issues raised – this is the issue of the availability of high definition (HD) services on the DTT platform. We consider this to be the most plausible argument in favour of some form of intervention when considering whether a market-based approach might not maximise the value to society in relation to national DTT services.
- 6.135 The rationale for any intervention in the award to ensure the provision of HD services on the DTT platform appears to be based on several key premises:
- over time, HD may overtake SD to become the new “broadcasting standard” in the UK, just as colour television has overtaken black and white;
 - given the shift to HD, consumers may come to expect that all services, and in particular the PSB services, will be available universally in HD form, including on the DTT platform;
 - due to the capacity constraints faced by the DTT platform, it may not be possible to provide a sufficient number of services in HD on that platform without loss of services already broadcasting on the platform. In particular, there is concern that there is insufficient capacity to make the main PSB channels available in HD on DTT, unless extra spectrum is provided; and
 - the public service broadcasters would not be able to acquire the additional spectrum they required in an auction, as they would lack the resources to do so efficiently and / or they would not be able to co-ordinate effectively.
- 6.136 The implications of this argument are that over time, the requirement to make the main PSB channels universally available may become a requirement to make them universally available in HD; that this should be delivered via the DTT platform; and that a market-based award of the available UHF spectrum is unlikely to result in that as an efficient outcome (because it will not fully reflect the externality generated by the broader social value of this use of the spectrum).
- 6.137 We have given these issues serious consideration throughout the Digital Dividend Review. Each of them raises important questions about the future of broadcasting in the UK.
- 6.138 We believe that there are three key areas that need careful consideration in order to take a view as to whether the market-led approach to the release of the spectrum will maximise the value to society. These are:
- evidence on consumer views and expectations;
 - the options for the provision of the PSB services in HD; and

- the consequences of any intervention in a market-led approach and the alternatives available.

Consumer views and expectations

6.139 Ultimately, the evolution of the HD market will be driven by consumer demand for HD. The extent of this is currently uncertain. HD is currently a relatively expensive proposition, requiring consumers to pay a premium both for compatible TV sets and for pay-TV subscriptions. This is reflected in the research carried out for the DDR, in which many respondents currently see HD as a niche, luxury service, and perceive little additional consumer or broader social value from the provision of the main five channels in HD.

Figure 6.2 Importance of HD TV to consumers and society



Source: Holden Pearmain Research

Figure shows proportions ranking services first or second

QC2a/b: Please rank these new services in the order of importance you think they are to the country as a whole/to you individually. Proportion ranking services 1st / 2nd

Base: Total sample representing 89% of population, n = 1500

6.140 However, HD is a relatively new service, and many viewers currently have little knowledge or experience of it. Extrapolating future behaviour from current perceptions is unlikely to yield an accurate forecast for the development of the market. As the market develops, and the technology becomes more familiar, it is likely that interest will grow and attitudes will change.

6.141 As a result, it is possible that consumer demand could grow significantly, and that this could happen relatively quickly. Sales of HD-ready TV sets, particularly the larger plasma and LCD screens on which the benefits are most noticeable, are growing steadily, as are subscriptions to BSkyB's HD satellite services. Retailers and manufacturers have started to invest heavily in marketing HD-ready sets, particularly in the run-up to Christmas. Despite limited interest at present, there is a plausible scenario in which HD reaches a majority of UK homes over the medium-term, and viewers do come to expect and require most content to be available in HD, including the main five public service channels.

6.142 However, this is far from the only scenario. There is a great deal of uncertainty regarding the development of consumer expectations for HD TV and consequently whether or not the universal availability of PSB services in HD will generate significant broader social value in the future. Taking a firm view at this stage on the likely development of consumer expectations for HD services is extremely difficult, and likely to prove flawed in the longer term.

Options for the provision of PSB services in HD

6.143 If it did become a requirement to provide the main public service channels in HD, our analysis suggests that in fact there is a wide range of ways for the PSBs to achieve this, even in the absence of intervention in the award of spectrum. A number of these possibilities would allow the PSBs to offer their five main services to very wide coverage – to between 90% and 98.5% of the population. The options include:

- A: Making use of the additional capacity created by changes in transmission mode at switchover to launch HD services. This extra capacity is equivalent to another multiplex. By rearranging the services carried on the six DTT multiplexes, five PSB HD channels could be made available to at least 90% of homes with no loss of existing services. (These HD services would be carried on the commercial multiplexes, which are currently expected to have 90% coverage). However, rearranging the multiplexes would be a complex and demanding task;
- B: Increasing the coverage of the PSB HD services under option A by increasing the roll-out of commercial multiplexes. This could be done by increasing the number of sites from which those multiplexes are broadcast, from covering 90% of the country to 96%, without requiring significant extra spectrum. Some interleaved assignments would be required, but generally in areas with very low populations where there is no scarcity. This would involve extra transmission costs, but would expand the coverage of terrestrial HD services as well as other services carried on the commercial multiplexes;
- C: Deploying free-to-view satellite services (“freesat”) to deliver PSB services in HD. Freesat services already exist. It would also be possible to launch a new freesat platform, in competition with other existing platforms. Satellite services are not subject to the same capacity constraints as terrestrial television and a freesat platform could carry all PSB services in HD (and many other services) to cover up to 98% of UK homes (including outside DTT coverage). There would of course be costs to this option, and it would not serve the existing installed base of terrestrial aerials;
- D: Upgrading to more efficient compression technology, and replacing all existing MPEG2 DTT set-top boxes in the market with MPEG4-compatible equipment, which would allow more services to be broadcast on the existing multiplexes. This would require an upgrade in consumer equipment over time but ultimately could double the capacity of the DTT platform; and
- E: Acquiring additional spectrum for a seventh multiplex. If acquired at auction, the costs could be significant, and success is not guaranteed.

6.144 All these options are likely to be complex to deliver, and have different benefits and costs. However they are all potential responses to any future need to deliver PSB services in HD. It is also important to recognise that these options are not comprehensive, and not mutually exclusive, so there is a wide range of strategies that PSB broadcasters could adopt to make their services available in HD. The

possibilities are summarised in Figure 6.3 below, and are described in more detail in Annex 8.

Figure 6.3 Options for delivery of PSB services in HD

Delivery option	Potential benefit	Implications
A : Use extra capacity available at switchover and rearrange multiplexes	Provide 5 HD channels to at least 90% of homes with no loss of existing services	Some PSB services in HD carried on commercial multiplexes. Services across the six multiplexes rearranged.
B : Boost coverage of commercial multiplexes	Increase coverage of HD channels under option A from 90% to c. 96%	Additional transmission costs to expand coverage. Wider availability of all services on those multiplexes, not just HD.
C : Use freesat services to ensure universal availability of HD free-to-view	Deliver 100+ HD channels to up to 98% of homes (including outside DTT coverage)	Additional costs for broadcasting via freesat. New freesat platform proposed by some PSBs could enhance competition & choice, but viewers would need satellite dishes.
D : Upgrade DTT platform from MPEG2 to MPEG4	Scope for up to doubling of capacity of DTT platform when transition complete. Capacity could be used for many HD and/or SD services.	Existing set top boxes and integrated digital TVs are MPEG2. Viewers would need new set top box to receive MPEG4 services. Various options for managing the transition to maintain confidence of viewers.
E : Acquire additional spectrum for seventh multiplex	Offer 3 HD channels to up to 98.5% of homes	Large opportunity cost of spectrum and risk that this is not optimal use.

6.145 It is clear from the figure above that, even if consumers do come to expect that the five main PSB services should be widely available, there are a number of options which could meet this expectation. One of the options is that some of the available UHF spectrum is used for a new (7th) multiplex, which could carry HD services – however, the other options do not involve the use of additional UHF spectrum and it is therefore unclear that the availability of PSB channels in HD format is inextricably linked to the availability of further spectrum for DTT.

Consequences of intervention in spectrum

6.146 Earlier in this Section, we considered the potential consequences of any intervention in the award of spectrum. The main considerations here are the risk of regulatory failure (ie the probability that a regulatory intervention does not have the outcome that was intended, because the benefits are less than expected, or the costs larger) and the opportunity costs that may be associated with any intervention.

6.147 In this case, the PSB broadcasters have argued that digital dividend spectrum should be allocated to them, to carry the main PSB channels in HD on the DTT platform. This allocation would be in addition to the 256MHz allocated by the Government to terrestrial broadcasting in 2003.

6.148 An allocation of this kind would constitute an interventionist approach to the management of spectrum – interventionist, rather than market-led, in terms of the fundamental choice set out at the beginning of this section. It would necessarily involve constraining for some period the use of the spectrum to meet the purpose for which the intervention is being made – as it would be inconsistent to allocate the spectrum to HD on DTT, but allow it to be used for, say, mobile TV or wireless broadband. It would also involve, logically, providing the spectrum to the PSBs at less than its full market price (including option value) even if the PSBs did pay a fee for using the spectrum (Administered Incentive Pricing, or AIP). This must be the case, as otherwise no benefit could arise for the PSBs. The separate question of

whether the PSBs face failures in capital markets that would limit their ability to fund the acquisition of spectrum is addressed in Annex 8.

- 6.149 What, then, would be the consequences of intervening in the use of spectrum in this way? We think there is a significant risk of regulatory failure with intervention to support the provision of PSB services in HD on the DTT platform. We argued earlier that it was very uncertain that there would arise a requirement or expectation that the PSB channels would be available in HD on DTT. If an intervention were made, and the expected demand for HD services later failed to materialise, it is very likely that the spectrum would not be put to its optimal use.
- 6.150 The risk of regulatory failure is also high in this case due to the fact that it would be difficult to reverse, hence constraining the use of the spectrum (perhaps to a sub-optimal use) for many years.
- 6.151 There is also a problem with the incentives that would be created for the PSBs. If PSBs do not face a market discipline associated with the acquisition of extra spectrum (as they do other inputs such as land and labour) they will have incentives to use too much spectrum relative both to other inputs and to other potential users of spectrum. Their incentives to explore other options for delivering a particular outcome – like widespread availability of their services in HD – will also be diminished.
- 6.152 The opportunity costs of intervening to reserve spectrum could also be very substantial. An additional universal coverage multiplex for HD could require 12 of the 15 cleared channels, if it were to avoid many households having to acquire new aerials. The opportunity cost of using 12 channels for an additional universal coverage multiplex is likely to be very significant. It could be possible to offer a universal coverage multiplex using as few as six of the cleared channels, though this might involve some households requiring new aerials, and would also likely involve significant international negotiations whose outcome would be uncertain and which would be time consuming. Even if only six channels were reserved, the opportunity cost would still be material.
- 6.153 It therefore appears that both the risks and costs of intervening through the provision of spectrum, and the risk of regulatory failure, are significant in this case.

Assessment of case for intervening in spectrum for national DTT

- 6.154 On the basis of the evidence available, we do not believe that there is a compelling case for intervening in this spectrum award in order to reserve capacity for high definition services on DTT.
- 6.155 We have also considered in detail other arguments for intervening in a market-led award of the spectrum in relation to DTT, but we do not believe that any of these arguments would justify any such intervention. Our analysis and conclusions are set out in more detail in Annex 8.
- 6.156 However, we do believe that it is important that the available UHF spectrum is packaged in a way that is suitable for DTT services, given that DTT has been identified as a plausible high value use of this spectrum.

Question.12 : Do you agree with our proposal that we should not intervene in the award of this spectrum to reserve spectrum for DTT? Do you agree that we should package the spectrum in a way which is suitable for DTT use?

Summary

- 6.157 In light of our overall spectrum strategy, and our detailed consideration of the evidence for possible market failures, set out in this consultation document and Annexes, we are proposing to proceed with a market-led award of the available UHF spectrum.
- 6.158 The award will be designed to ensure that all likely users of the spectrum have an opportunity to acquire spectrum suitable for their needs. Particular attention will be given in the design process to the issues identified above, for example that the packaging of the interleaved spectrum is appropriate to the needs of potential local TV providers.
- 6.159 The principal exception to this approach is channel 69, which we propose to keep available for use by PMSE equipment such as wireless microphones and in-ear monitors. We propose to deregulate access to most or all of this channel for PMSE purposes by making the spectrum available on a licence-exempt basis. We also propose to ensure that capacity continues to be available in the interleaved spectrum for PMSE users until at least the end of 2012.
- 6.160 Figure 6.4 sets out in summary form the proposals we are making, in relation to the award process, in respect of the main uses discussed above.

Figure 6.4 Summary of Ofcom's proposals

Overall approach	Ofcom's proposal
Market-led or interventionist	In general, award spectrum in a way that allows the full range of potential uses and users – open to all technologies and applications, subject to essential technical limits, ie a market-led approach. Consider need for changes to financial and institutional frameworks to ensure that organisations with social goals can acquire spectrum at auction, or in the market, if this is the best use of their resources.
Candidate use	Ofcom's proposal
Community PMSE	Keep channel 69 available for PMSE use. Deregulate use of most or all of this channel by allowing use of PMSE equipment on a licence-exempt basis.
Professional PMSE	Transitional arrangements to safeguard access to spectrum until at least 2012. Package interleaved spectrum in way that facilitates PMSE use.
Low power uses	Defer judgement on whether digital dividend spectrum should be made available for low power uses pending outcome of this consultation.
Innovation reserve	Seek views on whether any spectrum should be held back from award against the possibility of future

	innovations eg in low power uses.
Mobile broadband	Ensure design of spectrum award does not prevent mobile broadband use.
Local DTT	Package interleaved spectrum in way that enables local DTT use.
National DTT	Package the spectrum in a way that enables national DTT users to acquire suitable spectrum. No further proposals in relation to award of spectrum.

Question 13 : Do you consider that we have included in our analysis the most material risks in relation to market failure?

- 6.161 But to reiterate, while we are not proposing to intervene at the level of the spectrum award in relation to securing any social benefits that potential services may offer, we fully recognise that there may be broader social benefits available from certain of the uses of the spectrum, for example in relation to national DTT - from increased access to new content, or to content in enhanced formats such as HDTV. Other services, such as mobile broadband, may also offer value to society.
- 6.162 As set out above, controlling the use of spectrum by imposing extra constraints looks like a poor way of responding to the presence of such externalities – which is one reason why some uses of spectrum that may bring a high value to society risk being under-represented in the outcome of an auction.
- 6.163 A better response is likely to be to ensure that those uses and users can acquire spectrum at auction or through the market, if this is the best use of the resources available to them. Ofcom is ready to assist with this work.

Section 7

Market-led award

Introduction

- 7.1 In the remainder of this document we set out the conclusions of our analysis to date on the form of market-led award that would likely be best suited to the specific circumstances of the award of the available UHF spectrum.
- 7.2 In order to do so succinctly, we present our analysis by reference to a particular strategic approach to the overall award, namely an approach in which there is minimal intervention in the award of the spectrum itself to mitigate risks of market failure caused by externalities – intervention to secure outputs which bring broader social value being achieved through other means. We do this not to prejudge the outcome of our consultation on the strategic options, but to provide an early opportunity for interested parties to comment on these more technical matters. It is likely that Ofcom will consult again on a number of these matters nearer the time of the award, and in light of our eventual decision as to the strategic approach to be taken.
- 7.3 In the remainder of this Section we set out further details of the overall strategic approach that we use as our baseline for the presentation of these matters; set out our reasons for believing that for the majority of the spectrum considered in this review, it would not be appropriate to make use of this spectrum licence-exempt; and set out our reasons for believing that an auction would be the most appropriate form of competitive award.
- 7.4 In the following Sections we consider the appropriate timing of the award (or awards); set out our current understanding of the spectrum requirements of the different potential uses of the spectrum that we have so far identified, and consider the implications for the appropriate packaging of the spectrum for award; set out some initial thoughts on the type of auction likely to be required to achieve Ofcom's objectives for this award; and finally discuss various non-technical aspects of the usage rights and obligations to be embodied in the licences to be awarded.

Baseline strategic approach

- 7.5 For the purposes of succinct presentation of the issues around the design of an appropriate market-led award process, we have based our presentation on a baseline strategic approach which assumes that:
- all of the cleared spectrum (channels 31 to 35, 37, 39 and 40, and 63 to 68) is to be awarded without restriction as to use or user (other than those technical constraints necessary to control harmful interference, and meet international obligations);
 - likewise channel 36, once the existing user has vacated the band and international agreement has been reached as to rights of future use;
 - channel 69 not to be included in this award process and should be made available for low power PMSE use on the basis that most or all use of the spectrum will be made licence-exempt;

- the retained interleaved spectrum (the ‘white spaces’ between DTT broadcasts in channels 21 to 30 and 41 to 62) to be packaged in a way that facilitates its acquisition and use for PMSE and local TV (although not to preclude other uses); and
- moreover, some of the retained interleaved spectrum to have an obligation attached to it, for some period of time, requiring it to be available on reasonable terms for PMSE; this obligation to persist until at least the end of 2012.

Licence exemption vs individual licensing

- 7.6 As noted in the SFR: IP and elsewhere, Ofcom has a duty (in Section 1AA of the Wireless Telegraphy Act 1949) to make regulations exempting the use of particular equipment from licensing if it is satisfied that its use for wireless telegraphy is not likely to involve undue interference. Ofcom has considered whether use of equipment in these bands would be suitable for licence-exemption.
- 7.7 As set out in Section 6, we propose that channel 69 should be made available for use by low power PMSE equipment and that most or all of this use should be on a licence-exempt basis. We are satisfied that this proposal would not result in undue interference.
- 7.8 However, the market assessment has revealed a wide range of potential uses of the cleared and interleaved frequencies, including Digital Terrestrial Television, mobile multimedia and broadband wireless access (see Section 4). Ofcom’s technical analysis indicates that deployment of most of these potential uses on a licence-exempt basis would be likely to result in significant interference, as most of these uses employ transmitters that operate at significant power levels, and as a result would create a large zone of potential interference. We do not therefore propose that spectrum should be made available on a licence-exempt basis for those uses.
- 7.9 It is, however, possible (as discussed in Section 6 and in Annex 9) that other applications might be identified that are suitable for licence-exempt use, not least given the rate of innovation in the sector. Ofcom is inviting views on this in response to this consultation.

Mechanism for award

- 7.10 Ofcom has considered what mechanism for award of the spectrum is likely to result in the most efficient outcome for the use of the spectrum. Ofcom set out its general view in the Interim Statement on the SFR:IP and in the SFR Statement that an auction mechanism is likely to be Ofcom’s preferred tool for assigning licences to use unused spectrum, where demand for the licences is likely to exceed supply. Having considered the particular circumstances of this spectrum band, Ofcom has concluded that an auction mechanism should be preferred.
- 7.11 Ofcom considers that an auction offers the most open, transparent and non-discriminatory method out of those available for determining who should be granted licences for this band. This is because in auctions, a bidding process is used to award licences to those bidders prepared to pay most for them. Auctions are therefore likely to lead to the spectrum rights being assigned to users that value them most highly, which will generally be those who are likely to use the spectrum most efficiently. By contrast, in Ofcom’s view, other assignment mechanisms are unlikely to be as effective in promoting optimal use of the spectrum for this award. Alternative assignment mechanisms include first come first served processes, where licences

are assigned to applicants in the order of their application, and comparative selection processes, where licences are assigned to the applicants that, in the regulator's judgement, best satisfy the selection criteria that it has set. A first come first served process would not be appropriate where demand for spectrum is likely to exceed supply - the first applicants may not be those who would make the optimal use of the spectrum and many applicants may come forward at the same time. A comparative selection process involves defining selection criteria and assessing candidates' submissions and so carries the risk of subjective judgements being made and of the spectrum not being awarded to the bidder(s) able to use it to maximum advantage.

- 7.12 Ofcom considers that this reasoning is as relevant to the digital dividend bands as it is to a number of other bands. Moreover, Ofcom considers that the evidence available suggests there is keen interest in acquiring spectrum in this band, and that it is very likely that demand will exceed supply. A well-designed auction process, including appropriate design of licence conditions and packaging, should give the maximum flexibility for the market to determine the use of the spectrum and the identity of the users. This will further reduce the risk of regulatory error and unnecessary intervention inherent in other approaches to assigning spectrum rights.
- 7.13 Earlier discussion in this document has identified that there are some uses of this spectrum that could bring broader value to society, but that may not be able to earn commercial revenues that correspond. However, we have also identified that intervening in the allocation of spectrum is not an appropriate response to this problem given that it is not likely to promote optimal use of the spectrum. Instead, we consider that the right answer is to ensure that potential users in this position operate in a financial and institutional framework that ensures they can acquire spectrum, at auction or in the market, if that is the best use of their resources in securing public service objectives.
- 7.14 Ofcom therefore considers that the available UHF spectrum, excluding channel 69, should be awarded by way of auction. The rest of the discussion in this document assumes, for the sake of clear presentation and simplicity, that this is the mechanism for award.
- 7.15 Ofcom's proposal to use an auction as the method for assignment, and Ofcom's other proposals relating to the details of the auction design, are derived from the objectives for the award, and in particular the overarching objective of maximising the value of the spectrum to society. It is not Ofcom's objective to raise revenue by means of spectrum auctions nor, given Ofcom's statutory duties, is this a consideration that Ofcom has taken into account.

Question.14 : Do you agree with our proposal to auction licences for the use of the available UHF spectrum?

Section 8

Timing

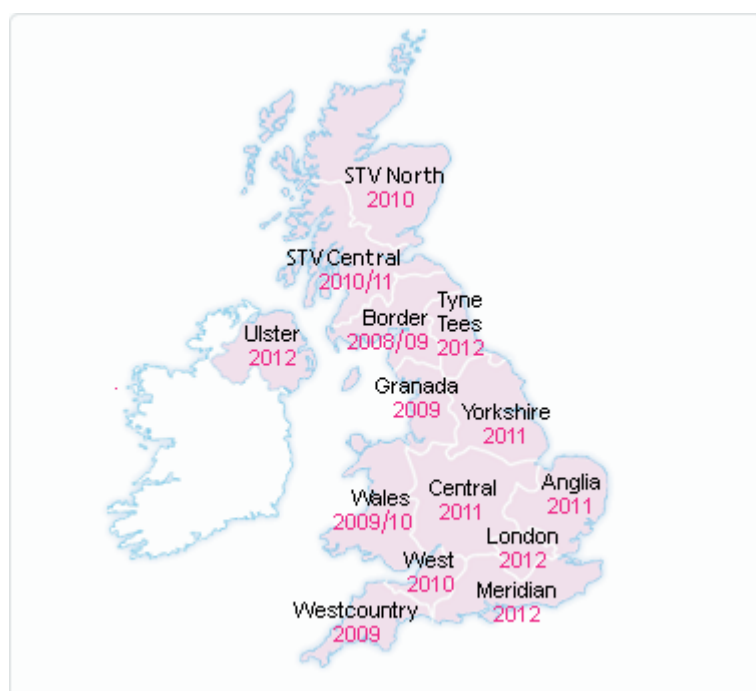
Introduction

8.1 In this Section we set out the current situation with regard to the anticipated timing of availability of the cleared and interleaved spectrum following DSO, the possible timing of the availability of channel 36, and the timetable for the holding of one or more auctions. On the basis of this information we set out some options for the timing of the award of the UHF spectrum, consider the merits of each option, and consequently make some proposals for consultation.

Timing of availability of cleared and interleaved spectrum

8.2 The spectrum released as a result of DSO will become available on a region-by-region basis, as DSO progresses, from 2008 to 2012. However no frequency channel will become available UK wide before 2012.

Figure 8.1 DSO timetable by region



Source: Digital UK

8.3 During the interim period between the start and end of DSO it should be possible to use the channels cleared by the switch-off of analogue television broadcasting in the regions where that switch-off has been completed, but only to the extent that such use does not interfere with continued use of those channels for analogue and digital television broadcasting in other regions that have not yet completed switchover (it will also be necessary to protect reception of analogue and digital television signals in neighbouring countries, and this requirement may extend beyond the final date for DSO in the UK).

- 8.4 Similarly the final pattern of interleaved frequencies, that will be available post DSO, should become available for use as switchover is completed in each region, subject to certain interim constraints necessary to protect services in adjacent regions and countries.

Possible timing of availability of channel 36

- 8.5 As noted above, channel 36 is currently used in the UK, and protected internationally, for ground-based aeronautical radar. However, only one remaining radar system operates in the band, and Ofcom has for some time now been in discussion with the CAA, and they in turn with the operator of the radar system, over the replacement of this radar system by one operating in a different band, which would allow this spectrum to be released for alternative use. These discussions have been positive and it seems likely that the spectrum can be released for alternative use. This is likely to take at least two years from a commitment to funding, to provide for physical replacement of the current radar system by a new one.
- 8.6 Under section 152 of the Communications Act 2003, Ofcom may provide a grant for changes such as this if it is likely to promote efficient use of the spectrum, with the consent of the Treasury. Ofcom has already begun discussions with the Treasury about this matter and it is intended to conclude these shortly.
- 8.7 Physical replacement of the current radar system by a new one is therefore likely to take a minimum of 2 years, ie not before the end of 2008. However, replacement of the existing radar system is not the only barrier to release of the spectrum for alternative use – it is also important that the UK secures international agreement to use of the band for other purposes.
- 8.8 The current international agreement covering use of channel 36 by the UK (the Geneva 06 agreement that came out of RRC 06) only covers use of the frequencies for ground-based aeronautical radar (at a total of five widely-distributed sites). The UK currently has no pre-agreed international rights of implementation or protection for any other use. We consider it essential that we reach some agreement with our international neighbours over future use of the channel before we make it available for new use. Reaching such international agreement is unlikely to be a quick process, although it is likely to take less time than that required to replace the radar. Ofcom considers that some clarity and certainty may be possible by the end of 2007, but is unlikely any sooner.
- 8.9 In short, vacation of the band by the existing user so that it may be used for some new use, together with final international agreement over rights of implementation and protection for any such new use, may therefore be possible by the end of 2008, but it is not likely to be feasible earlier than this.

Timetable for the holding of an auction

- 8.10 It is important to realise firstly that there is no legal bar to Ofcom holding an auction for the award of licences a number of years in advance of the relevant spectrum becoming available for use. Following such an auction, Ofcom would simply issue licences that made it clear that the rights of use of the spectrum did not start until some specified future date (although in some circumstances it might be open to the licensee to negotiate earlier access to the spectrum with incumbent users). The timing of the holding of an auction is therefore a separate (but related) matter from the timing of the availability of the spectrum for use.

- 8.11 The earliest that Ofcom is likely to be able to hold an auction for the award of licences to use the UHF spectrum following DSO is the second half of 2008. The timetable for the holding of such an auction would be as follows:

Figure 8.2 Indicative timing for the award process

December 2006	This consultation published
March 2007	This consultation closes
Before summer 2007	Publication of statement following this consultation and second consultation on detailed proposals for award
Before end 2007	Second consultation closes
Q1 2008	Publication of statement following second consultation, Information Memorandum and draft Regulations for statutory consultation
Q2 2008	Publication of statement following consultation on draft Regulations and making of final Regulations
Summer 2008	Regulations come into force
H2 2008	Auction held
Late 2008 / early 2009	Licences awarded

- 8.12 To be clear, the above timetable is the earliest that it is likely to be possible for Ofcom to hold an auction for the award of these licences. It would be relatively easy to postpone such an auction, if it was decided that this was desirable, but it is unlikely to be possible to reduce the elapsed time of c.16 months required from the point at which detailed proposals for an award are published for consultation, to the completion of the auction and the award of licences.
- 8.13 Even if it were decided to hold an auction for a small subset of the UHF spectrum on a stand-alone basis (for example channel 36), all of the same steps would continue to be required. And whilst it might be possible to shorten the period of time required for consultation and the drafting of relevant documents, in particular if the proposals were uncontentious, nonetheless the overall elapsed time from when it was decided to proceed with such a separate award, through to the completion of that award including the issuing of licences, would be unlikely to take less than 9 months.
- 8.14 Moreover whilst it may be possible to proceed with some of the first steps of preparation for an award in the absence of full clarity and certainty over future usage rights, it is unlikely to be appropriate to proceed with the formal legal steps necessary for the implementation of such an auction, ie publication of draft Regulations for statutory consultation, prior to the attainment of such clarity and certainty. Completion of any award in less than six months following the attainment of such clarity and certainty is therefore unlikely.
- 8.15 In the case of channel 36 we believe that the minimum requirement to achieve the requisite clarity and certainty is to have resolved the international position and to have a clear path to vacation of the band by the existing user. The earliest that it would be likely to be possible to hold and complete an auction for the award of channel 36 on a stand-alone basis is therefore the middle of 2008 (assuming that clarity and certainty over future use could be achieved no later than the end of 2007).
- 8.16 For the avoidance of doubt a very similar timetable would likely be required if it was decided to use a different form of competition to select the parties to whom licences

should be awarded, for example a comparative selection process (ie a 'beauty contest'), although the exact nature of the documents and processes would change.

Other relevant considerations as to the timing of award

- 8.17 DTT broadcasters would like to deploy the infrastructure for any additional multiplexes at the same time as implementing DSO, since this will minimise their costs. Hence they would like to know as soon as possible whether or not they have been successful in securing spectrum.
- 8.18 Similarly, the planning and deployment of new networks to exploit the digital dividend spectrum for other purposes is likely to take a minimum of one to two years from acquisition of spectrum to the launch of commercial services (and could potentially take substantially longer). Prospective users will therefore wish to know some years in advance of the spectrum being available that they have secured access to it.

Timing options and proposals

- 8.19 From the above discussion of the timing of the availability of channel 36, and the elapsed time necessary to prepare and hold an auction, we see that we are unlikely to be able to hold a stand-alone auction for the award of channel 36 far in advance of the earliest date at which we could hold a larger auction for the award of all of the UHF spectrum becoming available as a result of DSO – at most a few months.
- 8.20 A standalone auction of channel 36 in advance of any auction for the rest of the digital dividend also risks an inefficient outcome. Of particular concern is the possibility that the most efficient use of channel 36 might be in combination with other digital dividend channels. Bidders that wished to use channel 36 in this way would have to bid for it in any standalone auction without any certainty that they would win the complementary channels in the subsequent main digital dividend auction. Faced with this risk (which bidders interested in channel 36 alone would not face) there is a material risk that the bidders interested in channel 36 as part of a larger package would bid overly conservatively and consequently fail to win channel 36 when it would be efficient for them to do so. Alternatively they may over-bid and win channel 36 when it would equally be inefficient for them to do so.
- 8.21 We therefore have strong reasons for preferring a simultaneous award of channel 36 with the other cleared channels of UHF spectrum if possible. It would therefore seem undesirable to proceed with the award of channel 36 on a standalone basis in advance of the award of the other cleared channels, unless there was some reason to postpone the award of the other cleared channels for a significant period of time, and that reason did not extend to channel 36.
- 8.22 So far as the other cleared channels are concerned, we have seen above that Ofcom could, in principle, hold an auction for licences to use these frequencies as early as the second half of 2008. The question is whether that would be the appropriate thing to do, or whether there might be reasons to delay the auctioning of some or all of the frequencies for a period of time.
- 8.23 Considering first the question of whether it would be appropriate to delay the auctioning of some, but not all of the frequencies, we note above the strong reasons that we have for preferring a simultaneous auction of all of the cleared channels, reflecting the very strong complementarities and substitution possibilities between the different frequencies. In these circumstances we consider that there would have to be very real evidence of a material benefit in delaying the auctioning of part but not

all of the cleared spectrum, in order for us to contemplate the risk of the inefficient outcome that could be a very real possibility if we were to split the auction into two or more parts. We have to date been unable to identify any such clear benefit, although as we note in Section 6 we consider that a case might be made for deferring the award of some spectrum against the possibility of future innovation, particularly in low power devices. For the time being at least we consider it most likely that we would wish to proceed with a simultaneous award of all of the cleared channels.

- 8.24 So far as the appropriate date for such an auction is concerned, Ofcom's starting position is that any delay in making available spectrum for new uses risks a loss of consumer benefits as a result of consequent delays to the availability of new services, or to reductions in prices from increased competition. Delay may also lead to additional costs, for example if the roll-out of a seventh DTT multiplex cannot be undertaken simultaneously with the engineering work necessary to implement DSO. Any proposal to delay the auctioning of spectrum would therefore have to be justified by evidence of a likely benefit for consumers and citizens on at least a comparable scale to these potential opportunity costs.
- 8.25 A potential argument in favour of delay is that it would likely reduce uncertainty for some or all bidders and therefore potentially improve the outcome of the auction process – and would therefore be more likely to lead to an assignment of the spectrum to uses and users that was, ex-post, the most efficient.
- 8.26 It has to be recognised, however, that any auction is not the one and only opportunity for the market to decide what this spectrum should be used for and by whom. Ofcom expects to make this spectrum tradable, and for the licences to be technology- and use-neutral. The market will therefore have a continuing opportunity to change the ownership and use of this spectrum through the secondary market. Were this to be possible at little cost (and if information about the value of spectrum in different uses were widely known), the benefits of any delay in the initial award of the spectrum would likely be correspondingly low – the secondary market could be relied upon to correct any error in the initial assignment of the spectrum quickly and efficiently.
- 8.27 We cannot however rely upon the secondary market being entirely efficient and low cost. We have to accept that the market may be somewhat inefficient and the costs of achieving a reassignment of the spectrum quite high. In these circumstances there could well be a benefit in delaying the initial award of the spectrum if by doing so the costs of reassigning the spectrum through the secondary market could be reduced or avoided, or if a more beneficial outcome could be achieved than would be likely through the secondary market (if the secondary market were unable to reassign the spectrum to its most efficient use). But to be clear, it has to be recognised that the relevant comparison is not between the efficiency of the outcome of an early award vs a later award, but rather between the efficiency of outcome of an early award with the possibility of subsequent spectrum trading (albeit potentially only partial and at a cost) and the outcome of a later award.
- 8.28 In this context it is important to recognise that uncertainty is an all pervasive and apparently enduring feature of the electronic communications sector today – it is almost inevitable in the rapidly developing world in which we operate that, whenever we choose to award a piece of spectrum, there will be some new service or technology on the horizon that promises much, but the success of which is subject to considerable uncertainty. Even if an award is delayed the chances are that there will still be considerable uncertainty associated with many of the uses to which the spectrum might be put, and consequently a risk that the outcome will, ex-post, be seen to have been less than fully efficient. There is unlikely ever to be a time (at least

in the near future) when there is not material uncertainty affecting the award of a piece of spectrum.

- 8.29 In practice therefore, given the potentially significant additional costs and benefits foregone that could arise as a consequence of delay, we are inclined to think that delay would only likely be justifiable in those circumstances where we could be confident that a relatively short delay would give rise to a significant lessening of uncertainty with regard to the value of this spectrum. To be justified, the benefits of such a deliberate delay would need to clearly outweigh the costs of releasing the spectrum later. One example of an impending event that might justify a delay of this kind would be if a binding European regulatory decision were expected within a relatively short timeframe and it was likely that this decision would significantly constrain the potential use of the spectrum.
- 8.30 We are not currently aware, however, of any specific event in the near future that is likely to lead to such a material reduction in uncertainty. We are therefore currently inclined to believe that it would be most appropriate to hold any auction for the award of licences to use the UHF spectrum as soon as possible compatible with an orderly process, rather than to wait until some later time in the future. We will, however, keep this situation under review.
- 8.31 So far as timing of the award of licences to use the interleaved spectrum is concerned, for the same reasons as discussed above, we currently see no reason, not to hold an auction as soon as possible compatible with an orderly process. The question of whether the interleaved spectrum should be auctioned alongside the cleared channels in a single simultaneous auction, or should be auctioned separately, either just before or just after any auction of the cleared channels, is a matter of auction design and hence discussed below in that context.

Summary of proposals for consultation

- 8.32 The proposals on which we are now seeking views are as follows:
- that any auction for the award of licences to use the cleared channels be held as soon as possible compatible with an orderly process – currently expected to be in the second half of 2008;
 - that channel 36 not be auctioned any sooner than this, but rather be included with the cleared channels in the main auction (assuming that clarity and certainty as to rights of use can be achieved in sufficient time); and
 - that any auction for the award of licences to use the interleaved frequencies be held as soon as possible compatible with an orderly process – similarly expected to be in the second half of 2008.

Question 15 : Do you agree with Ofcom's proposals as to the timing of any auction? If not, what alternative proposal would you make and why, and what evidence and analysis can you provide in support of your alternative proposal?

Section 9

Spectrum requirements and packaging

- 9.1 In this Section, Ofcom describes a number of alternative options for the packaging of the rights and obligations to be granted under the wireless telegraphy licences to be made available.
- 9.2 Ofcom's wider principles for spectrum management, as discussed in Section 5, suggest that, in general, decisions on how spectrum is used should be left to the market rather than determined by the regulator. However, spectrum needs to be 'packaged' in some way in order for Ofcom to make it available to the market. It is therefore important that this is done in a way that facilitates efficient use and enables the maximum flexibility in how the spectrum can be used by the wide range of services which have been considered in this consultation.
- 9.3 In order to achieve this, Ofcom needs to have an understanding of the most likely uses of the spectrum, and to consider how this can be reflected in the packages offered to the market. This includes assessing the most likely technologies to be deployed in the band and consequently packaging the available spectrum in lots depending on the requirements of these technologies. Although potential users will have the ability to aggregate or disaggregate spectrum packages after the initial award, and to change use within the terms of their licences, attempting to assign spectrum efficiently through the initial award process is in keeping with Ofcom's statutory duties.
- 9.4 The proposals and alternatives presented below have been prepared in light of the objectives identified for the award and in light of Ofcom's statutory duties. They take into account all the relevant evidence that is available to Ofcom, including the outcome of the technical studies and technical, market and economic analysis commissioned by Ofcom as part of the DDR project³².
- 9.5 It should be noted that in any spectrum award, packaging and auction design are closely linked; some of the issues that may improve the likelihood of an efficient allocation of spectrum may be addressed through either packaging or auction design. As result this Section should be read in conjunction with Section 10 that looks at auction design.
- 9.6 Issues that should be considered when looking at packaging of the digital dividend spectrum include suitability for likely uses, effect on auction design and the effect on interference, particularly at boundaries.
- 9.7 This Section firstly looks at issues related to geographic coverage and then looks at specific packaging options.

Geographical coverage

Cleared spectrum

- 9.8 In the analysis of potential uses of the cleared spectrum, stakeholders have expressed a clear preference in providing UK wide services and very limited interest in providing regional services. Also the technical analysis at Annex 10 and the

³² <http://www.ofcom.org.uk/consult/condocs/ddr/>

consultants' report published alongside this consultation, shows that significant technical problems would be caused if different types of services were to share a UHF channel.

- 9.9 In general it is more spectrally efficient to allocate spectrum across the UK as a whole rather than at a more granular level. This is because it avoids the need for different services using the same frequency channel to be geographically separated (in order to avoid causing co-channel interference between two different operators and / or two different types of service).
- 9.10 Similar co-channel constraints apply when considering using the same channel for services in adjacent countries. The main impact of these international constraints is to limit the coverage of certain services in areas near the border with the adjacent country due to incoming interference or to limit the level of outgoing interference from UK-based services to protect services operating in the neighbouring country. In both cases it is for the operator to assess whether the service being considered for use in any particular channel can operate within the international agreements current at the time of the award. The possible impact of these constraints on a range of different services is discussed in more detail in Section 3 and Annex 10.
- 9.11 It is possible that improvements in levels of allowable interference, or other relevant changes to neighbouring countries' use of the spectrum, may be secured through bilateral co-ordination between respective spectrum administrations and operators. However, Ofcom is unable to confirm at this stage whether any such changes may be possible, and if so to their possible extent. Therefore any potential spectrum operator should not rely on these in their own assessment on whether any particular channel is suitable for their particular application.
- 9.12 In addition, most of the potential users have reported that they do not believe it would be realistic for their planned services to be offered at a regional or local level, with the exception of potential local TV operators.³³ Therefore if the spectrum were to be offered as a series of regional packages, a prospective UK-wide operator would either have to acquire all relevant regional packages in order to put together sufficient spectrum for a national service or else they would have to rely on the secondary market to acquire sufficient spectrum to satisfy their coverage requirements.
- 9.13 The secondary market may, however, not yet be sufficiently mature to support this approach – leading to possible delays in services being available for consumers. Moreover, relying on the secondary market may increase complexity due to the possible need to negotiate with multiple spectrum right holders in order to secure sufficient spectrum to achieve the desired level of coverage. A further consideration is that relying on the secondary market could take a significant amount of time, with the associated costs from delay that this would entail.
- 9.14 On the other hand, if a bidder is only interested in offering a portfolio of regional services, they would be able to purchase spectrum for that purpose and if desired, sell-on unused spectrum on the secondary market. Spectrum trading potentially offers greater scope for regional use to emerge post award from a national licence than for national use to emerge if regional licences were awarded to different parties. This is because, in the latter scenario, there is likely to be greater scope for complexity, cost and inefficiencies since several licensees are likely to be required to trade with an operator seeking aggregation to a national level as opposed to a

³³ However, given that the digital switchover is scheduled to take place on a region by region basis it may be possible for new services to be rolled-out regionally.

regional operator selling parts of a national licence which would potentially only need to deal with one counterparty.

- 9.15 Ofcom therefore considers, taking all these issues into account, that the cleared spectrum should be offered on a UK-wide basis.

Interleaved spectrum

- 9.16 There may be benefits in packaging the interleaved spectrum geographically. In contrast to demand for the cleared spectrum there is substantial demand from some operators, notably potential local TV operators, for at least some of this spectrum to be allocated in local or city-wide packages. However the various benefits of UK wide packages as described above are still relevant. As a consequence there seem to be three broad options for the geographic packaging of the interleaved spectrum:

- allocate all of the interleaved spectrum in one or more UK wide packages;
- allocate all of the interleaved spectrum as a series of local packages; and
- allocate the spectrum in a mixture of UK wide and local packages.

- 9.17 In general it is difficult for the regulator to determine what the geographical areas for non-national licences should be and it is not clear how potentially conflicting views from potential candidates for use could be resolved ahead of an award. However, in this case the technical constraints created by existing users and by the requirements of local television and PMSE make it relatively easy to identify appropriate geographic areas.

- 9.18 The choice between options will in part depend upon the requirements of the services that are likely to wish to use this spectrum. This issue is therefore discussed in more detail in the discussion on interleaved packaging below.

Packaging options

- 9.19 In deciding what packaging approach is most appropriate for the available UHF spectrum, Ofcom needs to take into account the range of potential uses that exists as well as their frequency requirements. It also has to take into account the extent and nature of the constraints that limit the use of this spectrum across the UK. One key feature of these constraints is that the GE-06 Agreement allocated the digital dividend spectrum in 8MHz channels across Europe for uses compatible with digital broadcasting. Any technical conditions relating to the interference that services can generate or concerning incoming interference that these services will have to accept will therefore relate to these specific 8MHz channels.

- 9.20 Ofcom therefore proposes that the packages of this spectrum consist of one or more 8MHz channels.

- 9.21 There are a variety of different services that could be deployed in the digital dividend and the amounts of spectrum they require vary widely. The technical analysis (see Annex 10) has shown that it is possible for two or more of these technologies to use adjacent frequency channels (albeit there may be a need for a guard band between the technologies). It is therefore feasible that a combination of these technologies could eventually be deployed in these bands.

- 9.22 It would be necessary to consider whether the value of specific blocks in these bands could vary as a result of the type of service deployed either within the band or in adjacent spectrum. If there were significant variations then the packaging options would also have an impact on auction design. For example, if there is demand for both small and large amounts of contiguous spectrum and individual lots are therefore made relatively small, then the auction design will need to take into account potential aggregation risks for bidders seeking the larger amounts of spectrum.
- 9.23 It is also possible to create packages that include both cleared and interleaved spectrum. However there has not been any significant expression of demand for this type of package. Further, potential operators would have the ability to bid for both types of spectrum in the auction even if these two types of spectrum were not packaged together. As a result, Ofcom proposes that the cleared and interleaved spectrum are packaged separately, and therefore the remainder of this chapter considers packaging for the cleared and interleaved spectrum separately.

Cleared spectrum packaging options

- 9.24 It is feasible for the cleared spectrum to be packaged in a variety of ways ranging from combining all of the cleared spectrum in a single lot to making it available as 15 individual 8MHz lots. The desired outcome of the process will be to aid an efficient allocation of spectrum. However identifying which combination of packaging and auction design will achieve that goal will require trading off of a number of factors including:
- flexibility for the market to determine the distribution of the spectrum;
 - the risk that users will not be able to aggregate spectrum to create usable packages; and
 - the complexity of auction design.
- 9.25 There are three broad options for how the cleared spectrum could be packaged:
- 15 individual 8MHz packages;
 - a solution with between one and 15 packages; and
 - a single package of all 120 MHz (ie 15 x 8MHz).
- 9.26 There are a number of advantages and disadvantages relating to any of the packaging options for the cleared spectrum. One key issue is that there may be a trade off between providing flexibility for bidders in an auction, and reducing uncertainty and interference issues. Providing greater flexibility may suggest an auction of individual 8MHz lots, which would be more likely to enable bidders to assemble their preferred package. However, this would also involve a more complex auction process (due to the number of packages) and greater complexity in determining interference issues. The option of a single package comprising all 120MHz would simplify the auction design and process, but would limit bidders' ability to acquire the specific lots they prefer. However, this approach might result in fewer interference issues between different services, and potentially a less risky auction for bidders.
- 9.27 The following Sections discuss each option in greater detail.

15 individual 8MHz packages

- 9.28 The spectrum could be packaged as individual 8MHz blocks. It is not clear that there is significant demand for services that only require one spectrum block apart from the case of channel 36, which is subject to the outcome of international negotiations. However it may be the case that some potential services that require multiple spectrum blocks may wish to have the ability to put together non-contiguous packages of spectrum to address particular needs eg specific coverage requirements.
- 9.29 As discussed in Section 3 and Annex 10 each of the UHF channels is subject to different constraints (ie they are subject to different levels of incoming interference from neighbouring countries and are allowed to transmit different levels of interference to other countries). This results in some channels being able to provide higher levels of coverage for services, possibly at lower cost, than others. It is likely that a common requirement of a number of the different likely uses for the spectrum will be that they will wish to achieve high levels of coverage to the UK population (including in areas such as the south and east of England which are near neighbouring countries where these constraints are at their greatest). Because of the varying geographical set of constraints they may therefore require more than one 8MHz channel to achieve this in a cost effective manner.
- 9.30 Even if not all of the spectrum is packaged as individual 8 MHz blocks, there may be a case for considering packaging specific channels (such as channel 36) individually if they can be realistically used alone.
- 9.31 In addition a number of the potential technologies require more than one spectrum block in order to be deployed, or specific groups of channels to support specific service options (eg paired spectrum requirements for FDD systems or separate groups of channels for universal coverage of a DTT service). This suggests that in general packages should be larger than single 8MHz blocks, or the auction design should allow services to aggregate packages of more than 8MHz.

A solution with between 1 and 15 packages

- 9.32 The technical characteristics of a number of the potential uses of the spectrum mean that if they operate in adjacent channels the likelihood that they will interfere with each other at the package boundaries increases. As a result the greater the number of packages the greater the risk of interference, and so the greater the requirements for other techniques to mitigate that interference. Therefore creating fewer packages is one approach that could increase the likelihood of an efficient award while subjecting users to a less complex set of usage rights and obligations. The following paragraphs look at the options for spectrum blocks larger than 8MHz.
- 9.33 If packaging is to reduce boundary issues, the packages offered by the regulator should consist where possible of contiguous spectrum. While it is possible to create non-contiguous packages of spectrum, non-contiguous packages would not address boundary issues. Therefore this analysis focuses on contiguous spectrum packages, however ways of allowing the market to obtain non-contiguous spectrum through the auction are discussed in Section 10.
- 9.34 Given the existing uses of the spectrum there are a number of “natural” boundaries in the band. As can be seen in Figure 9.1 below the need to accommodate existing users splits the spectrum that is available for new uses into 3 blocks. These blocks

are therefore the largest contiguous blocks that could be auctioned so these have been taken as the starting point for looking at packages between 8MHz and 120MHz.

Figure 9.1: A potential starting point for packaging of the cleared spectrum

Channels	21 – 30	31 – 37	38	39 – 40	41 – 62	63 – 68	69
Existing users	DTT		Radio Astronomy		DTT		
Available		Block 1		Block 2		Block 3	

9.35 Annex 10 discusses the different range of services that could make use of the cleared and interleaved spectrum and identifies their varying spectrum requirements. These are discussed below and the conclusions are summarised in Figure 9.2 and 9.3. Given their particular technical issues, DTT and the other services are initially addressed separately with the analysis drawn together at the end.

9.36 As identified in Sections 4 and 6, the PSBs and other organisations have shown interest in using the available UHF spectrum to provide DTT services. Given that DTT services are a potential use for the spectrum, Ofcom will attempt to ensure that a potential DTT user could, if they wished, acquire sufficient spectrum to offer DTT services. In the case of the PSBs, this may mean that high coverage DTT multiplexes would be required. Ofcom has therefore included in its considerations on packaging a number of options for the provision of DTT multiplexes in this spectrum, under a range of different coverage requirements.

9.37 The technical studies summarised in Annex 11 have shown that in order to provide high levels of coverage for a DTT multiplex, a range of spectrum packages can be considered. The analysis highlighted the following options for DTT:

- one package requiring twelve channels (incorporating most of Blocks 1, 2 and 3) which would provide near universal coverage and enable the broadcaster to operate within the domestic aerial groups used by the existing DTT services. This option also has a relatively low international co-ordination risk³⁴ as it makes use of one of the layers³⁵ agreed at the GE06 conference. However, this option requires most of the available cleared spectrum and a package linked to this would allow very little flexibility for other potential services;
- one package requiring six channels either from Block 1 or Block 3. This requires significantly less spectrum than the earlier example and would fit easily within the existing blocks. However, whilst high levels of coverage are possible with either of these packages there is a high international co-ordination risk associated with both. Also because the channels used are located solely in the top or middle of the band approximately a third of households would have to upgrade their aerials in order to receive DTT services which used these channels; and

³⁴ Any new configuration of the existing GE-06 assignments will have to be agreed with the UK's international neighbours. There is a risk that this co-ordination process will not yield the agreements necessary to allow these amended plans to be adopted resulting in less coverage than predicted or greater implementation cost for the broadcasters or reception costs for viewers.

³⁵ The UK has been allocated 8 layers in the Geneva 06 plan. Each layer contains sufficient assignments to enable a single DTT multiplex to be broadcast from all of the main transmission sites around the UK.

- one package requiring a combination of channels from across the band, that is three channels from Block 1 (channels 31 – 33) and three from Block 3 (channels 63 – 65). This package would allow a DTT service to make maximum use of the GE06 assignments and hence would have a relatively low co-ordination risk and would generally operate within the existing aerial groups hence minimising aerial upgrade requirements. This package therefore appears to be particularly attractive to a potential DTT operator and should therefore be considered when deciding upon the packaging arrangements in the following paragraphs.

9.38 Figure 9.2 summarises these and a number of other ways in which the spectrum could be configured for the provision of DTT services. It should be noted that this is not a exhaustive list of alternatives. Configuration of spectrum for DTT is discussed further in Annex 10. Configurations DTT #1 to #4 look at some of the options that may be able to provide coverage similar to current analogue TV coverage. For these it is assumed that a DTT operator wishing to reach this level of coverage would broadcast their service from all 1,154 transmission sites.

9.39 Configurations DTT #5 and #6 look at options which require fewer channels, but conversely have lower coverage, although they still allow much of the UK to be covered.

Figure 9.2 Summary of potential DTT spectrum configurations

DTT configuration	Coverage	Typical spectrum requirements per DTT multiplex	Spectrum issues	Comments
DTT #1	Near 98.5%	12 channels	Using all available GE06 assignments at all UK sites, requires use of channels 31 – 34, 38, 39 and 63 to 68	Very few households requiring aerial upgrade. Minimal international negotiations required. Sufficient capacity for additional DTT multiplex similar to national channel
DTT #2	Near 98.5%	6 channels	Uses channels 63 to 68	Would require 1/3 of households to replace aerials. Significant international negotiations required.
DTT #3	Near 98.5%	6 channels	Uses channels 31 to 34 and 38 to 39	Would require 1/3 of households to replace aerials. Significant international negotiations required.
DTT #4	Near 98.5%	6 channels	Uses channels 31 to 33 and 63 to 65	Would require less than 5% households to replace aerials. Some international negotiations required.
DTT #5	70% to 80%	Single channel	Requires channel 36 with suitable international clearances	To operate using a nationwide single frequency network (SFN). Coverage is dependent upon international co-ordination. Would require at least 1/3 of households to replace aerials

DTT configuration	Coverage	Typical spectrum requirements per DTT multiplex	Spectrum issues	Comments
DTT #6	60% to 95%.	3 - 5 channels	Assume multi frequency network (MFN) hence individual assignments scattered across UK. Can use contiguous or two blocks	Coverage dependent upon international clearances and hence the larger the number of channels used the better the overall coverage Fewer households would have to upgrade aerials if frequencies used matched current aerial groups hence two block solution better

9.40 As discussed in Section 4 there is a wide variety of other services and technologies that could make use of the cleared spectrum. Figure 9.3 shows that a single cellular operator, a single mobile multimedia operator or a single BWA operator could make use of groups of channels ranging from a single channel (which might be channel 36 depending on the outcome of international negotiations) to between three and five channels. The figure also shows that, in general, mobile multimedia services seem to be most interested in packages of spectrum in Blocks 1 and 2 (due to possible interference to GSM900 services if they share a handset with a GSM mobile communications service).

Figure 9.3 Summary of potential spectrum configurations for services excluding DTT

Service type	Typical spectrum requirements per service	Spectrum issues	Comments
Mobile multimedia – SFN	1 channel	Channel 36 may be preferred	If Channel 36 use can be agreed internationally for medium power use in UK this configuration could enable high levels of coverage at reasonable cost
Mobile multimedia – MFN	2 – 3 channels	Does not have to be contiguous but may need to avoid adjacent channel to existing DTT if guard channel required (see Section 3)	This probably requires spectrum below 750MHz if use is integrated with GSM handsets. Key constraints are international co-ordination and protection of existing DTT. Service could operate with minimum of one channel but lower risk and roll-out costs if two or three are used.
Broadband Wireless access (TDD)	1 - 5 channels	Must be contiguous	Key issue is whether in band uplink is possible. If DTT only requires protection for adjacent channel then single guard band of one channel (or possibly less) will enable high coverage at reasonable cost.
Mobile comms (FDD)	1 + 1 channels	See separation discussion in Annex 10.	Each service requires two 5MHz paired channels separated by 75MHz or 250MHz. Other separations could be considered including the use of spectrum outside the UHF band for the uplink service.

Service type	Typical spectrum requirements per service	Spectrum issues	Comments
PMSE	N/A	Using interleaved capacity	Main constraint on use is the need to protect DTT services using interleaved channels. Not expected to require all interleaved spectrum except in certain high use areas such as near theatres, studios, outside broadcast venues and major exhibition sites. See separate reports by Sagentia and Quotient.

- 9.41 Section 3 notes that some services may have to limit their use of channels adjacent to the interleaved spectrum in order to minimise interference to the reception of DTT services. These services may therefore have to operate a guard band of at least one channel in order that they can operate successfully in the blocks under consideration. This implies that operators should have the ability to acquire blocks of more than one channel adjacent to the interleaved spectrum (and to channel 38) to allow reasonable opportunities for operators to optimise their services within these constraints.
- 9.42 Although, as described in Section 3, the UK currently has no rights of protection in Channel 36 for services other than radar it is possible that some rights could be negotiated with our international neighbours. Dependant on those rights channel 36 could be used to provide eg a single DTT multiplex, or a single mobile multimedia service. There may be some demand for services such as mobile multimedia that could use channels 35 and 37 together or independently. In addition, channels 35-37 together could be used for a single cellular operator or a single BWA operator.
- 9.43 Therefore there may be a case to split Block 1 (channel 31-37) into two smaller blocks. Two options can be considered, both of which would seem to be equally suitable for most of the likely services:
- option 1: One block would cover channel 31-34 and another would cover channel 35-37; and
 - option 2: One block would cover channel 31-33 and another would cover channel 34-37.
- 9.44 All of Block 2 (channels 39-40) would probably be required by an operator that wished to operate a single mobile multimedia service. It could also be used by mobile voice and data operators for a number of networks, providing that adjacent channel and uplink issues are resolved, or these channels could be used by a DTT operator to extend coverage. Therefore there may not be a case to split this block any further.
- 9.45 All of Block 3 (channels 63-68) might be required by operators that wished to operate either a number of mobile multimedia services, one DTT service, or one or two BWA services. As it is possible to use some of this block combined with a similar amount of spectrum from Block 1 for DTT services this block could be split into two three channel packages. In that event any operator that wished to operate using all six channels would therefore have to acquire both packages.
- 9.46 In summary, one way of packaging the spectrum in multiple contiguous block may be to split Block 1 and Block 3 into smaller packages as shown in Figure 9.4 below.

This option would have fewer boundaries than offering 15 individual 8MHz packages, and this may make it easier for parties to participate in the auction and reduce the risks associated with acquiring suitable spectrum. However there are also risks to this option, including reducing the flexibility for the market to acquire other combinations of channels.

Figure 9.4 Another option for packaging the cleared spectrum

Channels	21 – 30	31 – 37		38	39 – 40	41 – 62	63 – 68		69
Existing users	DTT			Radio Astronomy		DTT			
Available		Block 1A	Block 1B		Block 2		Block 3A	Block 3B	

A single package of all 120 MHz (ie 15 x 8MHz)

- 9.47 Given the wide range of potential uses for the available UHF spectrum, and that there appears to be enough spectrum available to support at least two of these uses (potentially more), it does not appear appropriate to offer the spectrum in only one lot of 120MHz.
- 9.48 Further, Ofcom has a duty to promote competition where appropriate and despite the existence of a secondary market, competition law, fully tradable spectrum and service and technology neutrality there is a risk that if all of this spectrum was allocated to a single user competition would not be promoted downstream. No use has been identified that would require all of the spectrum that would be made available in this award. Therefore there does not appear to be a strong case to package the spectrum as a single lot.

Summary

- 9.49 An overview of some of the packaging options for the cleared digital dividend spectrum together with their respective advantages and disadvantages is given in Figure 9.5 below. This figure also explores some further options for creating spectrum packages larger than 8MHz. Our initial view is that the options involving four lots or more are likely to be preferable.

Figure 9.5 Summary of the advantages and disadvantages of possible packaging options for the cleared spectrum

Number of lots	Channels	Advantages	Disadvantages
Single lot	31 - 37, & 39 - 40, & 63 - 68	Quick and simple award process Maximum opportunities for the secondary market	Spectrum may be allocated inefficiently and relies on an efficient secondary market (which may take time to develop) Potentially restricts the development of competition and variety of applications
3 lots	31 - 37 39 - 40 63 - 68	Reduces aggregation risks for the majority of services Reduces interference issues at block boundaries to the minimum possible	Potentially restricts the development of competition and variety of applications Provides more spectrum than is required for all services Spectrum may be allocated inefficiently and relies on an efficient secondary market (which may take time to develop)
4 lots	31 - 34 35 - 37 39 - 40 63 - 68	Reduces aggregation risks for the majority of services Reduces interference issues at block boundaries	May restrict the development of competition and variety of applications
4 lots	31 - 33 & 63 - 65 34 - 37 39 - 40 66 - 68	Reduces aggregation risks for the majority of services Reduces interference issues at block boundaries	May restrict the development of competition and variety of applications Creates an additional boundary between channels 65 & 66
5 lots	31 - 33 34 - 37 39 - 40 63 - 65 66 - 68	Reduces aggregation risks for the majority of services Reduces interference issues at block boundaries	May restrict the development of competition and variety of applications Creates an additional boundary between channels 65 & 66
15 x 8MHz channels	All cleared	Promotes competition Market can determine optimum aggregation Maximum accommodation of alternative uses	Not clear that a single 8MHz block is usable for any services Interference issues at block boundaries are significantly increased More complex award process

Question 16 : Do you have any views on which of the packaging options identified for the cleared spectrum would be most suitable?

Interleaved spectrum packaging options

9.50 In Section 6 Ofcom set out its proposals for three specific actions affecting the interleaved spectrum:

- to offer packages of spectrum that are suitable for potential local television operation in as many parts of the country as is feasible;

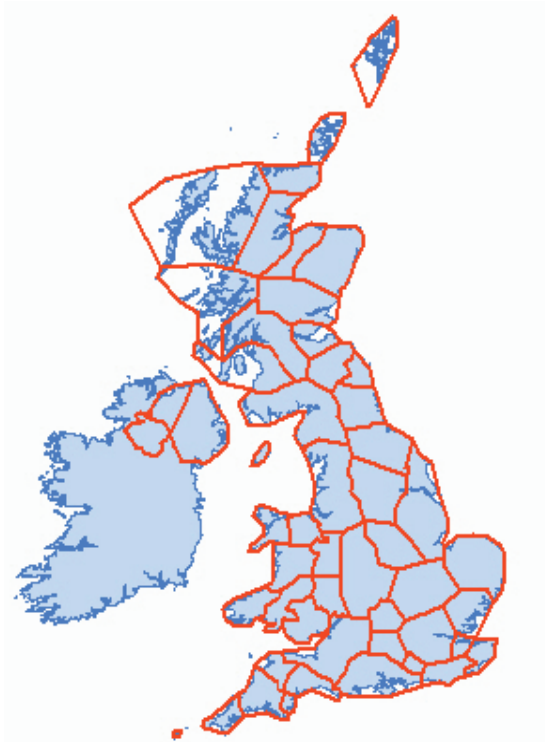
- to offer a number of packages of interleaved spectrum nationwide that are suitable for use by PMSE for professional users; and
 - to include in the licences for these latter packages obligations to make the spectrum available for PMSE use, for at least a transitional period until the end of 2012.
- 9.51 Ofcom has commissioned two pieces of work to help it better understand how local television and PMSE services could make use of the interleaved spectrum. The key conclusion from the Sagentia report is that there is sufficient capacity in the retained interleaved spectrum for all of the current professional PMSE use (including that for special events) which currently uses the interleaved channels (assuming that channel 69 also continues to be available). The LS telcom report found that it is possible to identify at least one assignment at most terrestrial broadcast main stations which would allow the broadcasting of a low capacity multiplex suitable for carrying local television services.
- 9.52 Ofcom believes that in general these two uses of the interleaved spectrum are compatible. It should be possible to offer at least one package of spectrum suitable for an additional low capacity DTT multiplex in most main station areas considered by LS telcom and still have sufficient capacity to allow existing PMSE use to be accommodated within the remaining interleaved spectrum, although a number of the PMSE users will have to purchase new equipment to allow them to operate within the more restricted frequency range being considered.
- 9.53 However, the situation in London is more constrained than in the rest of the UK, and Sagentia conclude that there is only just enough spectrum available within the London area to accommodate the current level of PMSE use (including the most recent special events). If one or more channels is used for other purposes, for example a low capacity DTT multiplex, then this could constrain future growth of PMSE in London, and in particular may constrain future large scale special events, unless the industry adopts more efficient technologies or operating practices.
- 9.54 Ofcom's preference would be to offer at least one package of spectrum in London that could be used for local TV (or for low power PMSE but without an obligation to use spectrum for this purpose).
- 9.55 In the light of this analysis, it seems to us that the most appropriate form of packaging for the interleaved spectrum is likely to be as follows:
- to offer a sizeable number of packages of spectrum consisting of a single (interleaved) spectrum assignment that could be used to provide a broadcast-like service at moderate to high power from an individual main station transmitter. These packages would be suitable for local TV use, but the spectrum would not be reserved for local TV as there are other potential uses. One or two packages could be made available per main station area, in each of up to 50 main station areas. Our analysis suggests that there would be at least 40, and could be between 50 and 100 such packages³⁶; and
 - to offer a small number (perhaps one, two or three) larger packages of spectrum, consisting of the right to use a subset of the interleaved channels across the whole of the UK, while having to protect other services, in particular with respect

³⁶ Use would not be limited to such high-power, high-tower broadcast transmissions, but the usage rights would be compatible with such use.

to the transmission and reception of the six core DTT multiplexes, and also with respect to the services deployed in the interleaved channels assigned individually within each main station area as described above (also with respect to new services in the cleared spectrum).

9.56 The map in Figure 9.6 shows the 50 main station areas in the UK

Figure 9.6 : Main station areas



- 9.57 To maximise the utility of the channels that will be assigned individually, Ofcom intends to identify for this purpose, in each main station area, those interleaved channels capable of providing the greatest coverage when used to broadcast from the main station transmitter (even though use in this way will not be mandatory). Ofcom believes that this approach will maximise the likelihood that the use of this spectrum will generate maximum value to society. It should be noted however that use of these frequencies has not as yet been cleared internationally and so the degree of coverage that will be achievable is as yet unknown.
- 9.58 So far as the distribution of interleaved channels between the larger packages of spectrum are concerned, Ofcom has an open mind as to the most appropriate manner of distribution. Options include:
- one package comprising all the remaining interleaved capacity that is available;
 - grouping adjacent channels together, for example having one package consisting of channels 21 to 30 and another of channels 41 to 62; or
 - splitting the channels more evenly between packages so that the packages are more nearly identical, for example having one package consisting of channels 21, 24, 27, 41, 44, 47, 50, 53, 56 and 59, another consisting of channels 22, 25, 28, 42, 45, 48, 51, 54, 57 and 60, and a third consisting of channels 23, 26, 29, 43,

46, 49, 52, 55, 58 and 61 (channels 30 and 62 would also be included within two of these packages).

- 9.59 The first of these options has the obvious advantage of simplicity, and minimises the number of additional spectrum boundaries created, but offers no potential for competition between suppliers.
- 9.60 The second and third options would create the potential for some competition, but at the price of additional complexity. PMSE equipment is generally only tuneable across a narrow range of frequencies (a few channels) and is not generally able to tune across the entire range of interleaved channels. This may limit the ability of PMSE users to switch readily between different suppliers.
- 9.61 Packaging the interleaved frequencies into large packages of contiguous channels risks reducing competition in any future market for the supply of spectrum to PMSE users, if those users are restricted in their choice of supplier as a result.
- 9.62 The third option reduces this risk by creating the possibility of multiple suppliers holding spectrum suitable for use by most PMSE users. However at the same time it significantly increases the number of spectrum boundaries across which co-ordination may be required, potentially increasing cost and/or reducing efficiency of use. Whilst this may not be too much of a problem for PMSE use, it could be a significant barrier to the use of this spectrum for other purposes in future.
- 9.63 Alternative approaches to the make-up of these larger packages also include:
- regional disaggregation – for example having separate packages consisting of channels 21 to 30, and channels 41 to 62 (or some other split of the channels as discussed above) in each main station area;
 - greater frequency disaggregation – for example awarding each individual interleaved channel separately but UK wide; or
 - a combination of these two approaches – eg individual channels in individual areas.
- 9.64 In this latter case there may be little merit in separately identifying those channels best suited to the provision of local TV and packaging them separately, since every interleaved channel will be separately available in each main station area. However, the problem with this approach is that whilst it gives maximum flexibility to the market to determine the most efficient assignment of the spectrum to individual users, it does so at the cost of considerable complexity for both Ofcom and potential bidders (there would be over 1000 separate packages of spectrum on offer for the interleaved spectrum alone). Ofcom does not currently believe that this cost would be justified in this case, and is therefore minded to reject this option.
- 9.65 So far as the first alternative option is concerned, as noted above, some potential users of the interleaved spectrum might have demand for spectrum in only a limited geographical area, in which case some additional efficiency might be achieved through geographically disaggregating the primary award of the spectrum. It has to be noted however that such benefits would only materialise if the geographic areas of interest to different bidders were mutually compatible, and it should only be necessary to take steps to facilitate this outcome through the primary award if there are material barriers to it being achieved through the secondary market.

- 9.66 In the light of our proposal to make some interleaved spectrum available on a regionally disaggregated basis (one or two channels in each main station area) we are currently unconvinced of the merits of making the rest of the interleaved spectrum available also on a regionally disaggregated basis, in particular in the light of the additional cost and complexity that would be involved, but would welcome views from interested parties on this issue.
- 9.67 Similarly, given the material constraints that will be necessary on the use of individual interleaved channels, we can see little merit in making these available on an individual basis. We anticipate that most if not all prospective users who are interested in anything more than a single channel in an individual area, will want to combine channels in order to create something approaching a national footprint (at least across urban areas). Appropriate pre-packaging of the interleaved channels by Ofcom will therefore reduce aggregation risk for these bidders and at the same time avoid the need for an overly complex and costly auction process. Ofcom is therefore not minded to pursue this approach either.
- 9.68 So to summarise, Ofcom anticipates that the most appropriate way of packaging the interleaved spectrum will be as follows:
- to offer a large number of packages of spectrum consisting of a single (interleaved) spectrum channel that could be used to provide a broadcast-like service at moderate to high power from an individual main station transmitter. These packages would be suitable for local TV use, but the spectrum would not be reserved for local TV as there are other potential uses. One or two packages could be made available per main station area, in each of up to 50 main station areas. This would imply a total of between 50 and 100 such packages³⁷; and
 - to offer a small number (perhaps one, two or three) larger packages of spectrum, consisting of the right to use a subset of the interleaved channels across the whole of the UK, while having to protect other services, in particular with respect to the transmission and reception of the six core DTT multiplexes, and also with respect to the services deployed in the interleaved channels assigned individually within each main station area as described above (also with respect to new services in the cleared spectrum).

Question 17 : Do you have any views on which of the packaging options identified for the interleaved spectrum would be most suitable?

³⁷ Use would not be limited to such high-power, high-tower broadcast transmissions, but the usage rights would be compatible with such use.

Section 10

Potential auction designs

Introduction

- 10.1 In this Section we set out some initial thoughts on the type of auction likely to be required to achieve Ofcom's objectives for this award.
- 10.2 Ofcom has set out above its view that an auction is likely to be the most appropriate way of awarding almost all of the digital dividend spectrum. This Section sets out Ofcom's initial thinking regarding the auction designs which Ofcom could use in the auction of licences for the use of these bands. Ofcom has developed these proposals with advice from its independent auction advisers. Our thinking on the auction design for the cleared spectrum is further advanced than that for the interleaved spectrum, and we will give more thought to options for the interleaved spectrum where a simpler mechanism may be preferable.
- 10.3 As noted earlier, spectrum packaging and auction design are closely linked. As an example, if an operator needs 32 MHz of spectrum (either contiguous or non-contiguous) in order to provide its service, this need can be addressed either through packaging, ie by explicitly creating one or more 32 MHz packages that the operator can bid for, or through auction design, ie by creating an auction that allows a bidder to aggregate and configure 4 x 8 MHz blocks, with minimal aggregation risk.
- 10.4 Where there are alternatives, the choice of whether to address issues through auction design or spectrum packaging will depend on a variety of factors, all of which will ultimately relate to the implications for an efficient allocation of the spectrum. These factors include the complexity of the auction, the implications for technical compatibility, and whether any services are put at an unfair disadvantage without justification.
- 10.5 Policy makers have a number of choices at their disposal in defining how the auction should be designed. They have to set both the format of the auction and design the rules for running the auction and deciding on the winners. The choice of auction rules will often depend upon the format chosen. The format of the auction covers issues such as whether:
- the bidders can see each others bids (called an open auction) or whether each bid is secret (sealed bid auction);
 - bidders can bid for all lots at the same time or for one lot after another (simultaneous vs. sequential bidding); and
 - bidders bid for individual items, or combinations of items (known as combinatorial or package bidding).
- 10.6 The remainder of this Section examines some practical concerns in deciding upon an auction design, followed by a discussion on the key choices in selecting an auction format. A number of example auction formats for the award of the digital dividend bands are set out briefly at the end of this Section. It should be noted that some of the issues discussed in this Section in particular aggregation risk, may be addressed either through auction design or through spectrum packaging.

Practical concerns in auction design

10.7 An auction may produce more or less efficient outcomes depending on the details of the auction design and the context within which the auction takes place. The economic literature on auctions suggests that in auction design, as in other areas of regulatory policy, it is especially important to address issues such as encouraging participation in the auction, and reducing the potential for collusive behaviour. Some examples of issues to be taken into account in auction design are as follows:

- there may be asymmetries between potential bidders in the auction, as a result of differences in their current market position and the information available to them about the market opportunity offered by the spectrum, or because of differential access to finance (possibly as a result of capital market inefficiencies). This may encourage perceptions that some bidders (eg incumbent operators) are 'strong' and others (eg prospective entrants) are 'weak', even if in some cases, a 'weak' bidder might have the strongest business case. Where asymmetries are significant, weak bidders may be reluctant to invest time and effort in entering the auction, with the consequence that the auction may be less competitive and effective than it might have been. Auction theory and practice has demonstrated that open, multi-round auctions tend to discourage entry by 'weak bidders', who fear that they will simply be overbid until they lose. By contrast, the use of sealed bids and/or restrictions on transparency can help to ease the impact of asymmetries, as 'weak' bidders perceive themselves to have a better chance of winning. This may encourage competition within the auction; and
- some auction designs may be vulnerable to strategic behaviour by bidders attempting to influence the auction outcome in their favour. For example, (especially in auctions with pricing rules other than pay what you bid) it may sometimes be possible for strong bidders to collude, tacitly or otherwise, to fix the number of licences or influence the price that they pay. Similarly, in multiple round auctions, it is sometimes possible for bidders to use their bids to signal their intentions to each other, creating potential scope for tacit collusion to share resources or to restrict purchase prices.

10.8 A further potential problem that requires consideration when designing the format of an auction is the situation where bidders have a high degree of common value uncertainty (ie the good being auctioned has the same or at least a very similar value to all bidders, but bidders do not know what that value is eg due to incomplete information) on licences, such that they are potentially exposed to the problem of 'the winner's curse'. This arises because those bidders who over-estimate the value of licences in a common value setting are likely to win. Rational bidders should respond to this problem by reducing their bids relative to their best estimates of value. Nevertheless, the common value uncertainty faced by bidders can result in problems, either because differences in the assessment of common value may swamp small differences in the true value across bidders or because the winner's curse affects weak bidders more than strong bidders, exacerbating their disadvantages. Common value uncertainty can be eased by using open, multi-round auctions and high transparency, as bidders can learn from the bidding behaviour of competitors.

Key choices in selecting the auction format

10.9 There are a number of different auction formats available, which may be suitable for the award of multiple lots of spectrum frequencies. In selecting the appropriate format for this auction, it is helpful to consider four key choices in design:

- simultaneous or sequential sale of lots;
 - single round (sealed bid) or multiple rounds (ascending bids);
 - generic or specific lots; and
 - package (combinatorial) bidding.
- 10.10 With the support of independent auction advisers, Ofcom has come to the view that using a simultaneous, multiple round process is likely to be the most appropriate approach for the cleared spectrum. We will give more thought to the options for the interleaved spectrum where a simpler mechanism may be preferable. We also believe that it is likely to be more appropriate to use specific lots rather than generic lots. However, we have not yet come to a view as to whether it would be appropriate to use package bidding in this award. The following paragraphs discuss each of these issues in more detail.

Simultaneous or sequential sale of lots

- 10.11 If spectrum is to be awarded as multiple lots these can be sold either simultaneously (all at the same time) or sequentially (one after the other). An important consideration for this award is the substitutability and complementarity of the different spectrum lots. For most categories of bidders, multiple lots in this band would potentially be close substitutes. This means that bidders' preferences between lots will be significantly affected by the relative prices of individual lots. Further, the demand assessment identified that most bidders are likely to seek multiple lots, some on a contiguous basis. This means that lots are likely to be complementary.
- 10.12 The effect of this substitutability and complementarity of the different spectrum lots is that most bidders are potentially exposed to both substitution and aggregation risks. Substitution risk refers to the risk that a bidder may win one lot (or group of lots) when, at the prevailing prices, it would have preferred to win another lot (or group of lots instead) instead. Aggregation risk denotes the risk that a bidder may win a lot (or lots) but fail to win complementary lots.
- 10.13 Aggregation risk is relevant for a number of the services that are likely to use this spectrum. As discussed in Section 4 a number of the services that are likely to use this spectrum will require more than one 8MHz channel. For the cleared spectrum, depending on the packaging decision that is taken, the auction design may play a significant role in ensuring that the bidder can put together the packages of cleared spectrum that they require.
- 10.14 Aggregation risk may also be a particular issue if the interleaved spectrum is packaged into individual 8MHz lots that are allocated in individual MSAs as discussed in Section 9. This will create over 1000 individual lots some of which may be complements for some bidders. For example, if any bidders required the same specific frequency across the country (excluding any restrictions created by having to protect existing users), or if a bidder requires the ability to cover a certain proportion of the population or areas that do not correspond to the MSAs then they will need to have the ability to aggregate lots to meet their requirements.
- 10.15 Auctions with a large number of lots have been successfully carried out on a number of occasions, most notably by the FCC in the USA. Therefore, the number of lots is not of itself a problem. However, as with any auction design, the rules for any auction would have to be carefully designed in order to mitigate any risks.

10.16 Sequential auctions create severe difficulties for bidders where lots are either substitutes or complements. In a sequential auction, bidders must bid for one lot without knowing what the price of other substitute lots will be (eg substitution risk) or whether they will be successful in winning complementary lots (eg aggregation risk). By contrast, a simultaneous approach can allow bidders to manage aggregation and substitution risk across lots.

Single round (sealed bid) or multiple rounds (ascending bids)

10.17 Both single round, sealed bid and multiple round, ascending bid auction formats are commonly used for assigning radio spectrum. Sealed bids are often favoured for their simplicity and because, where there are significant bidder asymmetries and related concerns about the level of competition in the auction, they can encourage participation. However, in the absence of concerns about competition, multiple round auctions are considered to produce more efficient outcomes as bidders can learn from observing the behaviour of competitors over the course of the auction. Ofcom proposes to award the digital dividend spectrum through a multiple round process, as opposed to a single round sealed bid format, for the following reasons:

- in situations of common value uncertainty, the outcome of the auction will be enhanced if bidders are able to observe the behaviour of their rivals over the course of multiple rounds. Many of the technologies that could be deployed in this band are for provision of new services, so there is significant value uncertainty. At the same time, there may be bidders targeting very similar downstream markets, so they will have a high degree of common value. Hence, bidders may benefit greatly from being able to observe how their competitors shift demand – including both total demand and demand for specific lots – in response to prices;
- as discussed above, most bidders will face substitution and aggregation risks. If the auction does not enable bidders to respond to relative prices, lots might not be distributed to the bidders with the highest value, resulting in inefficient allocation. For example, bidders may end up paying a high price for some lots when substitute lots could have been purchased at a lower price. Alternatively, in terms of complementarities, bidders may fail to acquire sufficient contiguous lots, or they may bid conservatively, which might lead to them inefficiently failing to win a licence (ie risk of unsold lots). By allowing bidders to shift between lots and adjust their demand in response to changes in relative prices, these risks can be addressed;
- in a sealed bid, bidders would face considerable uncertainty over the interference environment they might be facing. By contrast, in an open bidding process, bidders are more likely to obtain information that would allow them to form expectations about their likely neighbouring users, and adjust their bidding behaviour accordingly; and
- no concerns about bidder asymmetries or competition have so far been identified which would be sufficient to justify use of a sealed bid as a way of encouraging entrant participation.

10.18 Although multiple round auctions are generally more complex to participate in than sealed bid contests, the benefits of simplicity are not so great that this could justify using a significantly less efficient auction format. Ofcom will ensure that bidders are well informed about the auction design and its procedures prior to the award, through bidder seminars.

- 10.19 It is also relevant to consider that while the mechanics of participating in a multiple round auction are generally more complex for bidders than participating in a single round sealed bid auction, in other respects a single round sealed bid auction can be more complex for bidders. This is particularly so where it is difficult for bidders to calculate the value of the spectrum that is available. As noted above, in a sealed bid auction, there is no opportunity for bidders to learn through the auction process. This means that in a sealed bid auction, bidders will potentially have to invest much more time and resource to calculate their willingness to pay for the available spectrum.
- 10.20 It is possible to combine the two approaches by concluding a multi-round process with a final sealed bid. In this award a hybrid approach may combine the benefits of both formats.
- 10.21 In an auction with multiple units that are both substitutes and complements, such as this, a simultaneous multiple-round auction process allows bidders some flexibility to manage substitution and aggregation risks, as they can respond to changes in prices and competitor demands by switching between lots. This flexibility is absent from a simple, sealed bid. However, substitution and aggregation risks may be more effectively mitigated by package bidding, which can be applied to both sealed bids and open auctions but, applying package bidding rules with large number of lots is potentially complex. In general, it is much easier to apply such rules over a single round rather than many rounds, so this is a potential advantage of using a sealed bid.

Generic or specific lots

- 10.22 The multiple lots available for award could be sold either on a generic or specific 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. The actual frequencies that they are awarded are allocated in a follow-up process.
- 10.23 The main advantage of the generic approach lies in the simplicity of the process for bidders; bidders only have to express the number of lots they want at a particular price. Ofcom then organises a follow-up process to actually allocate specific spectrum to winning bidders. Ofcom can do this in such a way that, for example, contiguous spectrum can be guaranteed. However, in such a generic approach the ability of bidders to express a preference between different lots is likely to be somewhat restricted. It is therefore important that there are no significant differences in value between lots if such a process is to be efficient.
- 10.24 In the case of the UHF spectrum it seems likely that bidders will attach rather different values to the individual channels that are available, both the individual cleared channels, and the individual channels within the interleaved spectrum, in light of the differing constraints that will exist on use of the different channels. If we were to pre-package the spectrum into larger groups of channels, it is even less likely that bidders would consider these to be close substitutes. It therefore seems unlikely that an approach based on undifferentiated generic lots will be appropriate in this case.
- 10.25 However, depending on packaging decision for the interleaved spectrum in particular, there may be a case for having some categories that contain generic lots. If this is appropriate it may simplify the auction design.

Package (combinatorial) bidding

- 10.26 Allowing package bidding can enhance the efficiency of an auction. In an auction with package bidding, bidders submit mutually exclusive bids for combinations of lots,

rather than making multiple bids on individual lots. Package bidding can improve the efficiency of SMRA formats in the specific circumstance when “(a) there are strong complementarities among licences for some bidders, and (b) the pattern of those complementarities varies for different bidders”³⁸. Because of the potential different downstream applications that the available spectrum could support, package bidding is potentially relevant to this auction given that bidders are likely to have demands for different numbers of contiguous lots and different bidders are likely to have demand for different specific lot(s).

10.27 Package bidding can improve the efficiency of an auction outcome, as it can address undesirable outcomes such as:

- stranded lots (ie aggregation risk); where bidders are left with unwanted lots at the end of the auction (due to a failure to win bids on other lots that were needed in combination with these). This is an inefficient outcome as there may be another bidder that would have been happy to buy these lots at a slightly lower price, but had exited the auction; and
- unsold lots; where lots are left unsold due to a sudden ‘step change’ in demand. This is an inefficient outcome as there may be a bidder that would have been willing to buy these unsold lots, albeit at a lower price.

10.28 Package bidding can reduce aggregation risks for bidders. This should encourage participation by bidders with different patterns of complementarities, resulting in more efficient outcomes.

10.29 However, these benefits should be weighed against the drawbacks of allowing package bidding. Generally, package bidding makes the auction more complex and less transparent, especially if bids for every possible combination of lots are allowed. These drawbacks can be eased by (a) restricting the bidders to certain combinations of spectrum and (b) limiting the number of package bids that bidders can make in one round.

10.30 It should be noted that with both the cleared and the released spectrum the issue of unsold lots can also be reduced through creating large spectrum packages. However this can create other issues such as the risk of spectrum being underused.

Possible auction formats for a digital dividend spectrum auction

10.31 Given the complementarity and substitutability of the spectrum, and the significant common value uncertainty with this spectrum it seems likely that a simultaneous multiple round auction will be appropriate in this case. However Ofcom has not yet formulated a specific view on the appropriate design of an SMRA auction in this case.

10.32 Examples of SMRAs that may be appropriate in this case are;

- a standard SMRA with pre-defined lots, which could be augmented by either limited withdrawals or augmented switching;
- a SMRA with pre-defined lots and package bidding;

³⁸ Public Notice DA 00-1486, US Federal Communications Commission, July 3 2000

- a clock/sealed bid hybrid with each lot as a unique category (equivalent to having pre-defined lots); or
- a clock/sealed bid hybrid with a more limited number of categories of generic lots.

10.33 These are described below:

Standard SMRA

- 10.34 Bidders make multiple, independent bids for pre-defined lots. Bidders can manage aggregation and substitution risks in two ways: by switching their demand between lots whenever they are overbid; or by withdrawing their current high bids, subject to possible penalties.
- 10.35 This is a proven auction format that has been used for auctions of 3G and FWA licences worldwide. It allows bidders to express their relative preferences between lots based on relative prices, and avoids the need for any follow-up process to assign actual lots to bidders.
- 10.36 The key drawback with this approach is that it creates an exposure risk for bidders, ie either winning spectrum on a non-contiguous basis or winning only a subset of the lots they actually wanted. As bidders are aware of this issue they may bid more cautiously than they would otherwise. Both of these issues create the possibility of an inefficient allocation of spectrum.
- 10.37 It is possible to reduce, but not eliminate, this risk through the use of augmented switching rules. Augmented switching refers to the situation where bidders that withdraw current high bids from lots are obliged to submit a corresponding number of new bids on other lots, but are not otherwise penalised for making withdrawals. This makes it simpler for bidders to switch demand across lots than is the case with the standard SMRA.

SMRA with package bidding

- 10.38 This is a variant of the standard SMRA that introduces package bidding, ie allowing bids for combinations of lots as well as for individual lots. In each round, bidders can submit mutually exclusive bids for every combination of lots that they would be content to win at the current prices. With large numbers of lots, package bidding can quickly become very complex. However, complexity can be reduced by constraining the types and/or numbers of combinations that bidders can bid on in each round of the auction.
- 10.39 The package auction progresses in a similar way to the standard SMRA. The auction continues for as long as there is excess demand, with prices increased in increments in each round. At the end of each round, a set of highest bids are identified, and these remain as highest bids unless displaced by a new set of bids in a later round with a higher aggregate value.

Clock/sealed bid hybrid

- 10.40 The clock/sealed bid hybrid is a two-stage auction format, consisting of a clock auction, followed by a sealed bid. This approach has been developed as an alternative to the standard SMRA which allows (limited) package bidding without introducing the complexity of a pure package bid SMRA. The objective is to eliminate aggregation risks without introducing undesirable complexity for bidders.

- 10.41 Clock auctions are a simple form of SMRA used for selling multiple generic lots ie where there are many similar lots which can be effectively allocated as a single category. In a clock auction, the price per lot is increased steadily over consecutive rounds, with bidders in each round indicating their demand for lots at that price. The auction continues until the price reaches a level where demand for lots is equal to (or less than) supply – the point at which ‘the clock stops’.
- 10.42 The clock/sealed bid hybrid deals with cases where lots being sold simultaneously are too different to be sold together as a single category, and must instead be divided into multiple categories. In each round of the auction, bidders submit a single package bid, in which they link demand across categories. The auction continues over multiple rounds, with prices rising on lots in those categories where demand exceeds supply. The auction continues until demand for lots in all categories is equal to or less than supply. Note that clock auctions often ‘overshoot’, meaning that there may be unsold lots at the end of the clock phase.
- 10.43 The sealed bid is a package bid auction in which bidders bid for specific combinations of pre-determined lots. All bids made in the clock phase roll over into the sealed bid phase. Bids in the clock phase apply to any applicable combination of lots from the associated categories. In addition, bidders that were still active at the end of the clock phase are allowed to augment these bids to reflect their relative preferences between specific lots (they may also be allowed to expand their demand in the case that there are unsold lots at the end of the clock phase). The lots are awarded to bidders based on the combination of mutually acceptable package bids with the highest aggregate total. There are a variety of possible pricing rules that can be applied, including pay-what-you-bid and opportunity-price type rules.
- 10.44 There are a number of potential concerns with this approach, these include creating an exposure risk if generic lots are used, bid shading in the sealed bid round, insufficient price revelation, and strategic behaviour.
- 10.45 Although there are some merits to generic lots in terms of auction design which are discussed in the figure below, generic lots are unlikely to be appropriate in this auction. Therefore each lot would be predetermined, would have a separate category and would have its own clock. This removes the concerns of creating an exposure risk as bidders are never exposed to winning a combination of lots that they do not want at the prevailing price.

Comparison of candidate formats

- 10.46 All of the auction designs described above may be suitable for both the cleared and the interleaved spectrum. However their suitability will, in part, depend on the decisions that are made on packaging.
- 10.47 When considering which of the auction designs may be appropriate for this band, a range of factors need to be considered, for example:
- aggregation (exposure) risk: This is the risk that bidders who require a specific quantity, or a specific configuration, of spectrum can not acquire all they require through the auction process. Exposure risk is the related risk that bidders who do not manage to acquire all the spectrum that they require are left holding unwanted spectrum blocks. This can create issues such as overly cautious bidding to reduce exposure risk;

- **threshold risk:** This is the risk that a group of bidders, each demanding relatively few lots, is not able to efficiently co-ordinate in order to displace a single bidder that wants a single larger package of spectrum. It creates a risk that a bidder demanding a few lots does not raise its bid in the hope that it can “free-ride” on the other bidders that do. If some, or all, of the smaller bidders do this then the group as a whole may not displace the single bidder, even when it is efficient for them to do so;
- **revelation of demand:** As discussed earlier, in this auction there is common value uncertainty (ie the goods being auctioned have the same, or at least a very similar, value to all bidders, but bidders do not know what that value is eg due to incomplete information). This means that bidders will benefit from a better understanding of the value that other bidders place on this spectrum. Information about other bidders’ demand for the spectrum can be revealed through the bids that are made in the auction. However the auction will need to be designed to efficiently allow the information to be revealed;
- **strategic behaviour:** The auction design will need to reduce incentives for bidders to deliberately act in a way that distorts the auction and so lead to an inefficient outcome; and
- **complexity:** The auction process will need to make it clear to bidders which decisions they need to make at each stage and what the impact of those decisions will be.

10.48 These issues as they relate to the auction designs under consideration are discussed in more detail in the figure below. In addition Figure 10.1 provides a general comparison of the auction formats across a number of additional criteria.

Figure 10.1 Comparison of candidate auction formats

	‘Standard’ SMRA	SMRA with package bidding	Clock-sealed bid hybrid with pre-determined lots	Clock-sealed bid hybrid with generic lots
Aggregation (exposure) risks	Potentially severe aggregation risks for bidders requiring large packages; can only be partially mitigated by activity rules	Eliminates aggregation risks for bidders without any constraint on flexibility to express demand for packages that are substitutes	Eliminates aggregation risks but may prevent some bidders from expressing demand for all packages that are substitutes (unless combinatorial clock format used)	Extent to which aggregation risks are mitigated depends on nature of categories and what constraints are put on the outcome of the sealed bid phase
Threshold risks	Not applicable to this format	May advantage bidders seeking larger packages at expense of coalitions of smaller bidders	Threshold risks diminished relative to package bid SMRA, but not eliminated (unless combinatorial clock format used)	Threshold risks largely eliminated

	'Standard' SMRA	SMRA with package bidding	Clock-sealed bid hybrid with pre-determined lots	Clock-sealed bid hybrid with generic lots
Revelation of demand	Bidders must bid for individual lots, so demand for packages of lots is not transparent	All potential demand for packages of lots can be revealed	Bidders are limited in their ability to express demand for substitute packages (unless combinatorial clock format used)	Bidders have some scope to express demand for substitute packages but information about preferences for lots within categories is suppressed
Vulnerability to strategic behaviour	Most vulnerable format, although much scope to use activity rules to mitigate worst risks	Limited scope for strategic behaviour; some concerns related to threshold bidding and strategic demand reduction	Limited scope for strategic behaviour; format is relatively robust to strategic demand reduction	Least vulnerability of all formats
Complexity for auction designers	Tried and tested format, although would require testing of bespoke activity rules	High complexity if large numbers of lots; requires complex pricing rule	High complexity if large numbers of categories; pricing rule is easier than for SMRA with package bidding	Using generic lots rather than pre-determined lots will reduce complexity
Complexity for bidders	Format is familiar and relatively easy to understand; but bidding strategies may be complex	Potentially complex if large number of packages and non-transparent pricing rule	In theory, bidding should be relatively straightforward	In theory, bidding should be relatively straightforward, with fewer options than format with pre-determined lots
Length of process	May take many rounds to complete	May take many rounds to complete	Length can be reduced relative to standard SMRA depending on bidding rules	Length can be reduced relative to standard SMRA depending on bidding rules
Compatibility with packaging options for: > Released spectrum	Not ideal for any of the packaging options given extent of aggregation risks	Potentially the most efficient solution for all packaging options; but concerns about complexity for options with larger numbers of lots	Could work for all packaging options; reduces complexity but may introduce inefficiency relative to package bid SMRA (unless combinatorial clock format used)	Could potentially work for packaging option with national lots, but requires careful design of constraints on package bid options
> Interleaved spectrum	Plausible stand-alone solution given that aggregation risks are relatively less severe	Likely to be too complex for packaging options with many lots	Not ideal for options with larger number of lots, owing to risk of inefficiency due to constrained substitution options	Could potentially work for packaging option with MSRs

	'Standard' SMRA	SMRA with package bidding	Clock-sealed bid hybrid with pre-determined lots	Clock-sealed bid hybrid with generic lots
> Integrated award	Not ideal for any of the packaging options given extent of aggregation risks	Likely to be too complex except in case that number of lots is severely constrained	May not be ideal for options with larger number of lots, owing either to risk of inefficiency owing to constrained substitution options or high complexity of implementation if combinatorial clock format used	Could potentially work with award under some packaging options (ie R1, I1, I2, I3)
Overall efficiency assessment	Known problems with aggregation risks and strategic bidding – may be acceptable but not ideal, especially for released spectrum	Most efficient solution in theory; but severe practical obstacles to implementation for packaging options with larger numbers of lots	Potentially attractive balance of efficiency and low complexity for modest numbers of lots; but efficiency in doubt for large numbers of lots	Could potentially increase efficiency and reduce complexity relative to having pre-determined lots, but only under specific packaging conditions

Source: DotEcon

Question 18 : Do you have any views on which of the auction design options would be most suitable?

Section 11

Usage rights and obligations

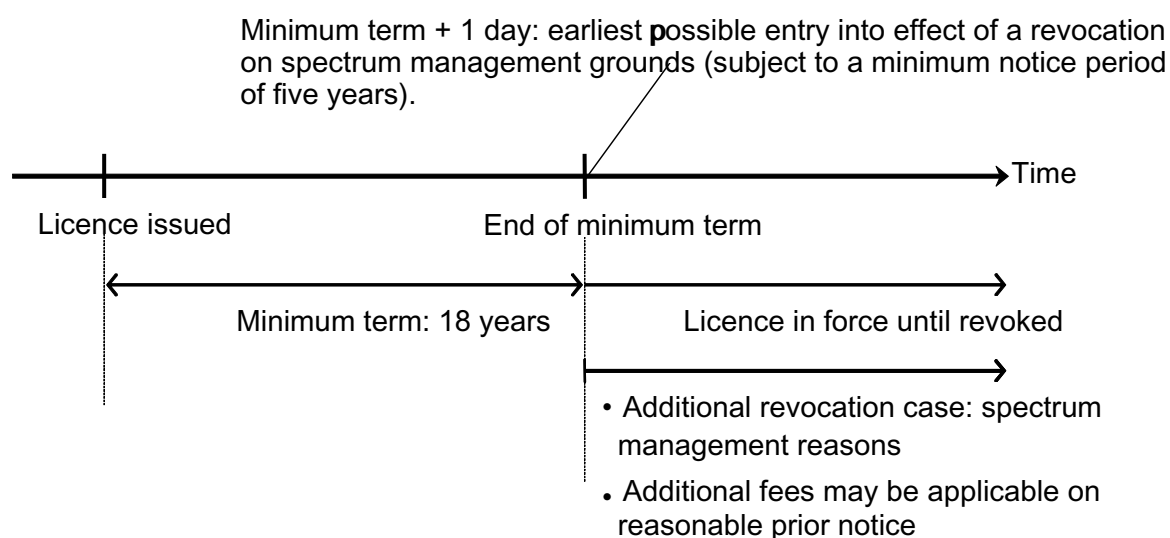
Introduction

- 11.1 In this Section we discuss various non-technical aspects of the usage rights and obligations that will need to be embodied in the licences to be awarded for the UHF spectrum.
- 11.2 This consultation does not deal with the detailed technical specification of usage rights, which will be addressed in future work by Ofcom. Information on the technical constraints on usage is, however, contained in Section 3 and Annex 10.

Licence term

- 11.3 It was proposed in the SFR:IP that new licences to be awarded by auction should generally have an indefinite term with a minimum period. During the minimum period the grounds for revocation by Ofcom would not include a general right to revoke for spectrum management reasons. After the end of the minimum period, the grounds for revocation by Ofcom would include such a right, subject to a minimum notice period of five years. Ofcom 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 minimum term.
- 11.4 The aim of these proposals was to provide licensees with a minimum period 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 minimum term should be linked to a reasonable view of the period required to earn a 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 minimum term. However, during this period Ofcom 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.
- 11.5 Consistent with the Interim Statement on the SFR:IP, we propose to take the following approach for licences issued for use of the UHF spectrum (both cleared and interleaved):
- the licences to have an indefinite duration;
 - the licences to have a minimum term of 18 years;
 - Ofcom to be able to revoke the licences before the expiry of the minimum term on the limited grounds set out below; and
 - Ofcom to be able to revoke the licences from any point after the expiry of the minimum term on the grounds set out below, but also for spectrum management reasons subject to Ofcom giving five years notice; it to be possible for Ofcom to give notice of revocation during the minimum term, for revocation to take effect after expiry of the minimum term.

Figure 11.1 Graphical illustration of the licence term



Rights during the minimum term

11.6 The proposed minimum term is designed to provide licensees with a high security of tenure for investment planning purposes. During that period, Ofcom 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.

11.7 During this minimum 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;
- in accordance with Section 4(5) of the Wireless Telegraphy Act 1998. That Section provides that notwithstanding any terms or provisions in a WT Act licence which restrict the exercise by Ofcom of its power to revoke licences, Ofcom may at any time, by notice in writing, revoke or vary licence terms if it appears 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 to Ofcom under Section 5 or Section 156 of the Communications Act 2003.

Rights after the minimum term

- 11.8 When the minimum term has expired, the licence will remain in force and continue to be held by the licensee. Two additional conditions will then also apply:
- one providing an additional power for Ofcom to revoke the licence on spectrum management grounds as described above; and
 - one allowing Ofcom to apply annual licence fees.
- 11.9 Whether an annual licence fee is applied after the expiry of the period of the minimum term will depend on Ofcom's general approach to fees for the use of spectrum at that time and how that general approach relates to these licences. Such fees could be set at a level to recover a share of the costs of regulation; they may alternatively be based on Administrative Incentive Pricing (AIP). This provision will allow for the potential application of AIP to the licensed use of the spectrum after the end of the minimum term if this is appropriate in the context of Ofcom's statutory duties. AIP presently plays an important role in incentivising efficient spectrum management, and Ofcom has stated that it expects to continue applying AIP after introducing spectrum trading in order to promote efficient use of the spectrum.
- 11.10 In July 2006 Ofcom published a consultation document "Future pricing of spectrum used for terrestrial broadcasting" which included consideration of AIP in digital television broadcasting. It should be noted that this stated that AIP should, in principle, apply immediately to any spectrum acquired for the purpose of broadcasting any new terrestrial service, unless such spectrum is acquired through an auction. This consultation closed in October 2006 and Ofcom is currently considering the responses.
- 11.11 Ofcom does not consider that it is necessary or appropriate to specify now the level of the annual licence fees, if any, that may be applied to the digital dividend bands after the end of the minimum term. Ofcom would expect to bring forward proposals on this matter to a timescale that gave the licensee reasonable notice of any relevant fees before they became payable.
- 11.12 Ofcom believes that it is necessary to include these additional licence conditions in relation to the licence period after the minimum term because of the need for the regulator to be able to intervene if required to promote efficient use of the spectrum. Ofcom has a high degree of confidence that the auction, including the payment of the auction fee, will secure efficient use of the spectrum during the minimum term. However, it is less clear that this objective will be met after the minimum term, or indeed for the entire indefinite duration of the licence. The longer the period over which the regulator is required to look forward, the greater the uncertainty that exists. At present, the ability to revoke licences on spectrum management grounds, and the ability to charge fees (including promoting optimal use of the spectrum) are important mechanisms in the regulator's toolkit. Ofcom considers that it is proportionate and objectively justifiable to include provisions allowing the regulator to take these steps after the end of the minimum term of these licences. Ofcom also considers that the inclusion of these provisions is transparent as to what it seeks to achieve and does not unduly discriminate against any person.
- 11.13 It is important to note that Ofcom would expect to give prior notice at the time of any specific proposal to use the power of revocation and variation, or the charging of fees, and to consult as appropriate.

Duration of the minimum term

11.14 To determine the duration of the proposed minimum term, Ofcom has considered the relevant period that provides a reasonable chance for the businesses that might be most likely to operate in the bands to make a return on their investment. This is based on assessments of;

- initial fixed costs and operating costs to exploit the spectrum;
- the time needed to roll out an operational service; and
- projected rates of uptake of services and associated revenues.

11.15 This analysis suggests that the minimum operational term of any licence needs to be in the region of 15 years. 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.

11.16 At the same time use of the cleared digital dividend spectrum will not be possible on a national basis until 2012, with for example use in London not being possible before then. Full commercial launch of services using the cleared spectrum is therefore unlikely much before the middle of 2012. 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.

11.17 As it happens three of the current DTT multiplex licences, if renewed, will reach the end of their renewed term in 2026 (12 years from 2014). Ofcom considers that there may be some merit in synchronising the end of the minimum term for the new licences to be awarded for the digital dividend spectrum with the end of the renewed term for the existing DTT multiplexes.

11.18 Ofcom is therefore minded to set the minimum term for the new licences to be awarded for the digital dividend spectrum so as to end in 2026. Assuming that the new licences were awarded in 2008 this would imply a minimum term of 18 years.

Spectrum trading

11.19 Ofcom has started the implementation of spectrum trading for selected licence classes in 2004, through the Wireless Telegraphy (Spectrum Trading) Regulations 2004³⁹. The changes, described in the Spectrum Trading Statement, published in August 2004, introduced the possibility for licensees in specific classes to carry out:

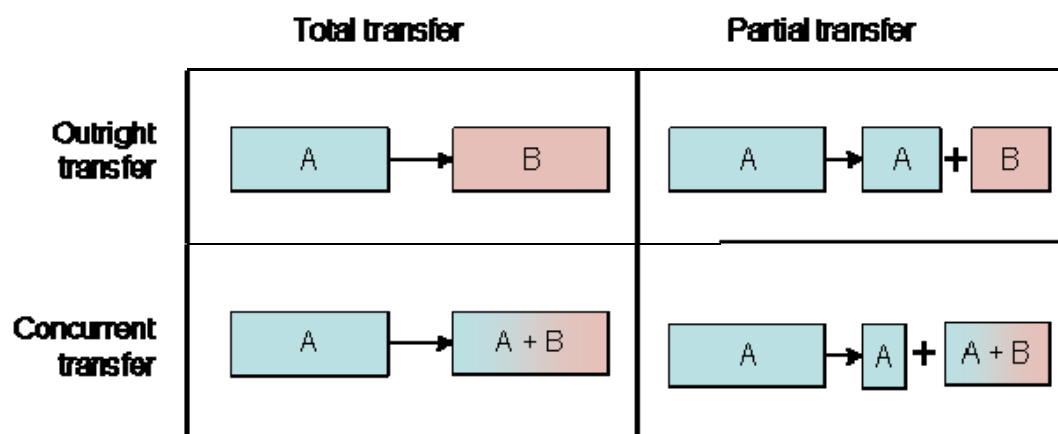
- outright total transfers, ie transfers of all of the rights and obligations arising under a licence to a third party;
- concurrent total transfers, ie transfers (of all of the rights and obligations arising under a licence) to a third party which result in a concurrent holding of those rights and obligations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

³⁹ Statutory Instrument 2004 No. 3154

- concurrent partial transfers, ie 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).

11.20 Figure 11.2 illustrates some possible types of transfers.

Figure 11.2 Illustration of some possible types of transfer



11.21 In the case of the digital dividend bands, Ofcom proposes to amend the Wireless Telegraphy (Spectrum Trading) Regulations to allow all of these types of transfer.

Non-technical restrictions on use

11.22 In the light of Ofcom's intention that the digital dividend spectrum be available on a technology- and use-neutral basis, we would not seek to impose any non-technical restrictions on the use to which the spectrum could be put ie no non-technical restrictions as to the technology that could be deployed, the equipment that could be used, or the service that could be offered.

Service obligations

11.23 Likewise, we would not seek to impose any requirement on licensees to offer any particular service to any particular user group or area of the country ie no roll-out obligations.

11.24 In the case of the interleaved spectrum, as previously noted, we propose an obligation on some licensees, for some period of time, to make spectrum available to others for PMSE use, on reasonable terms, at least until the end of 2012 in order to reduce the risk of serious disruption to the PMSE industry during the DSO process, and in the run-up to the 2012 Olympics.

11.25 We also do not intend to seek to impose any 'use-it-or-lose-it' type condition. The merits of such conditions have been considered previously, for example in the context of the Spectrum Framework Review: Implementation Plan. Ofcom is of the view that such conditions are in general unlikely to be justified as a means to promote optimal use of the spectrum, as this is better achieved through other mechanisms such as a competitive award process, spectrum trading, liberalisation and spectrum pricing.

Competition issues

- 11.26 As this spectrum award advances, Ofcom will need to give significant thought to competition issues, both in relation to the award of the spectrum itself (for example the rules relating to participation in the auction) and to competition in downstream markets which may be affected by the results of the award.
- 11.27 Ofcom's general approach to spectrum awards is to impose the minimum restrictions on the award and trading of spectrum. However, we will need to consider whether rules are necessary in this case on the amount of spectrum that could be acquired ('spectrum caps'), and whether it would be appropriate to include conditions in the licences awarded to help Ofcom secure fair and effective competition in downstream markets following the auction. We will also need to consider the relevance of competition law and the auction rules to potential participation by bidders.

Broadcast services

- 11.28 Prior to the Communications Act 2003, multiplexes used for digital terrestrial radio and television services had to be licensed under both the Broadcasting Act 1996 and the Wireless Telegraphy Act 1949. Section 241 and 258 of the Communications Act allow Ofcom to operate a simpler and more flexible regime, under which the use of spectrum for multiplexes carrying broadcast services can be licensed solely under the Wireless Telegraphy Act.
- 11.29 Ofcom would expect to use this new and flexible approach in relation to the digital dividend, removing the requirement for a Broadcasting Act multiplex licence to be held in addition to the spectrum licence. This is consistent with the technology- and use-neutral approach to spectrum proposed in this document. Individual programme services carried on these multiplexes (such as national or local TV channels or radio stations) would still be licensed under the Broadcasting Act in the same way as programme services broadcast on multiplexes that are authorised under a Broadcasting Act licence.

Other issues

- 11.30 Ofcom is in discussion with the authorities in the Channel Islands and the Isle of Man as to whether the licences awarded for use of the available UHF spectrum should extend to these territories.
- 11.31 We will also be considering how this spectrum award should take into account the 2012 London Olympics and Paralympics.

Summary of proposed licence terms

- 11.32 The main non-technical conditions that Ofcom is currently minded to include in the licences to be issued for use of the UHF spectrum are:
- licence term – indefinite, with a minimum term of 18 years during which Ofcom will have limited rights of revocation; possible for Ofcom to revoke on spectrum management grounds on any date after expiry of the minimum term, subject to Ofcom giving 5 years' notice; spectrum pricing to potentially apply after expiry of the minimum term;
 - tradability – the licences to be tradable; all legal forms of trading to be permitted;

- non-technical restrictions on use – the licences to 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
- service obligations – the licences not to contain roll-out obligations or ‘use-it-or-lose-it’ conditions, apart possibly from some relating to the future supply of interleaved spectrum for PMSE use.

Question 19 : Do you agree with Ofcom’s proposals for the non-technical terms of the licences to be awarded for use of the UHF spectrum?

Section 12

Next steps

- 12.1 This consultation, published on 19th December 2006, lasts for a 13 week period. The closing date for responses is 20 March 2007. See Annex 1 for details of how to respond to this consultation.
- 12.2 Ofcom will conduct a substantial programme of stakeholder consultation during January and February 2007, in order to allow its various stakeholders the opportunity to discuss the proposals contained within this consultation. Invitations to these events will be sent out in due course, and details of these events will be posted on the Ofcom website at <http://www.ofcom.org.uk/radiocomms/ddr/>
- 12.3 Ofcom expects to release a statement detailing its final proposals for this spectrum award in or around July 2007. Ofcom also expects to publish a further consultation at around the same time on certain issues of detail regarding this award, for example more detailed proposals on spectrum packaging and award design.
- 12.4 An indicative timetable for the award of the available UHF spectrum is set out below. This timetable is subject to a number of external factors beyond Ofcom's control (eg international developments), and so may be amended during the course of the award process.
 - 12.4.1 December 2006 – DDR consultation
 - 12.4.2 July 2007 – DDR Statement
 - 12.4.3 July 2007 – Second DDR consultation (on detailed proposals for packaging, auction design, licence terms, technical conditions, and draft regulations)
 - 12.4.4 February 2008 – Second DDR Statement
 - 12.4.5 February 2008 – Information Memorandum
 - 12.4.6 February 2008 – Draft regulations for statutory consultation
 - 12.4.7 April 2008 – Statement on regulations
 - 12.4.8 June 2008 – Regulations come into force
 - 12.4.9 July or September 2008 – Auction begins (or evaluation of applications)
 - 12.4.10 Late 2008 / early 2009 – Licences issued

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 20 March 2007.
- A1.2 Ofcom strongly prefers to receive responses using the online web form at <http://www.ofcom.org.uk/consult/condocs/ddr/howtorespond/>, as this helps us to process the responses quickly and efficiently. We would also be grateful if you could assist us by completing a response (see Annex 3), to indicate whether or not there are confidentiality issues. This response coversheet is incorporated into the online web form questionnaire.
- A1.3 For larger consultation responses - particularly those with supporting charts, tables or other data - please email Paula.guest@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.
- Paula Guest
Ofcom
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.

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 Paula Guest on 020 7981 3805.

Confidentiality

- A1.8 We believe it is important for everyone interested in an issue to see the views expressed by consultation respondents. We will therefore usually publish all responses on our website, www.ofcom.org.uk, ideally on receipt (when respondents confirm on their response coversheet that this is acceptable).
- A1.9 All comments will be treated as non-confidential unless respondents specify that part or all of the response is confidential and should not be disclosed. Please place

any confidential parts of a response in a separate Annex so that non-confidential parts may be published along with the respondent's identity.

- A1.10 Ofcom reserves its power to disclose any information it receives where this is required to facilitate the carrying out of its statutory functions.
- A1.11 Please also note that copyright and all other intellectual property in responses will be assumed to be licensed to Ofcom to use in order to meet its legal requirements. Ofcom's approach on intellectual property rights is explained further on its website at <http://www.ofcom.org.uk/about/accoun/disclaimer/>

Next steps

- A1.12 Following the end of the consultation period, Ofcom intends to publish a statement by the end of July 2007.
- A1.13 Please note that you can register to receive free mail Updates alerting you to the publications of relevant Ofcom documents. For more details please see: http://www.ofcom.org.uk/static/subscribe/select_list.htm

Ofcom's consultation processes

- A1.14 Ofcom seeks to ensure that responding to a consultation is easy as possible. For more information please see our consultation principles in Annex 2.
- A1.15 If you have any comments or suggestions on how Ofcom conducts its consultations, please call our consultation helpdesk on 020 7981 3003 or e-mail us at consult@ofcom.org.uk . We would particularly welcome thoughts on how Ofcom could more effectively seek the views of those groups or individuals, such as small businesses or particular types of residential consumers, who are less likely to give their opinions through a formal consultation.
- A1.16 If you would like to discuss these issues or Ofcom's consultation processes more generally you can alternatively contact Vicki Nash, Director Scotland, who is Ofcom's consultation champion:

Vicki Nash
Ofcom
Sutherland House
149 St. Vincent Street
Glasgow G2 5NW

Tel: 0141 229 7401
Fax: 0141 229 7433

Email vicki.nash@ofcom.org.uk

Annex 2

Ofcom's consultation principles

A2.1 Ofcom has published the following seven principles that it will follow for each public written consultation:

Before the consultation

A2.2 Where possible, we will hold informal talks with people and organisations before announcing a big consultation to find out whether we are thinking in the right direction. If we do not have enough time to do this, we will hold an open meeting to explain our proposals shortly after announcing the consultation.

During the consultation

A2.3 We will be clear about who we are consulting, why, on what questions and for how long.

A2.4 We will make the consultation document as short and simple as possible with a summary of no more than two pages. We will try to make it as easy as possible to give us a written response. If the consultation is complicated, we may provide a shortened version for smaller organisations or individuals who would otherwise not be able to spare the time to share their views.

A2.5 We will normally allow ten weeks for responses to consultations on issues of general interest.

A2.6 There will be a person within Ofcom who will be in charge of making sure we follow our own guidelines and reach out to the largest number of people and organizations interested in the outcome of our decisions. This individual (who we call the consultation champion) will also be the main person to contact with views on the way we run our consultations.

A2.7 If we are not able to follow one of these principles, we will explain why. This may be because a particular issue is urgent. If we need to reduce the amount of time we have set aside for a consultation, we will let those concerned know beforehand that this is a 'red flag consultation' which needs their urgent attention.

After the consultation

A2.8 We will look at each response carefully and with an open mind. We will give reasons for our decisions and will give an account of how the views of those concerned helped shape those decisions.

Annex 3

Consultation response cover sheet

- A3.1 In the interests of transparency, we will publish all consultation responses in full on our website, www.ofcom.org.uk, unless a respondent specifies that all or part of their response is confidential. We will also refer to the contents of a response when explaining our decision, without disclosing the specific information that you wish to remain confidential.
- A3.2 We have produced a coversheet for responses (see below) and would be very grateful if you could send one with your response (this is incorporated into the online web form if you respond in this way). This will speed up our processing of responses, and help to maintain confidentiality by allowing you to state very clearly what you don't want to be published. We will keep your completed coversheets confidential.
- A3.3 The quality of consultation can be enhanced by publishing responses before the consultation period closes. In particular, this can help those individuals and organisations with limited resources or familiarity with the issues to respond in a more informed way. Therefore Ofcom would encourage respondents to complete their coversheet in a way that allows Ofcom to publish their responses upon receipt, rather than waiting until the consultation period has ended.
- A3.4 We strongly prefer to receive responses via the online web form which incorporates the coversheet. If you are responding via email, post or fax you can download an electronic copy of this coversheet in Word or RTF format from the 'Consultations' Section of our website at www.ofcom.org.uk/consult/.
- A3.5 Please put any confidential parts of your response in a separate Annex to your response, so that they are clearly identified. This can include information such as your personal background and experience. If you want your name, address, other contact details, or job title to remain confidential, please provide them in your coversheet only so that we don't have to edit your response.

Cover sheet for response to an Ofcom consultation

BASIC DETAILS

Consultation title:

To (Ofcom contact):

Name of respondent:

Representing (self or organisation/s):

Address (if not received by email):

CONFIDENTIALITY

What do you want Ofcom to keep confidential?

Nothing	<input type="checkbox"/>	Name/contact details/job title	<input type="checkbox"/>
Whole response	<input type="checkbox"/>	Organisation	<input type="checkbox"/>
Part of the response	<input type="checkbox"/>	If there is no separate Annex, which parts?	

DECLARATION

I confirm that the correspondence supplied with this cover sheet is a formal consultation response. It can be published in full on Ofcom's website, unless otherwise specified on this cover sheet, and I authorise Ofcom to make use of the information in this response to meet its legal requirements. If I have sent my response by email, Ofcom can disregard any standard e-mail text about not disclosing email contents and attachments.

Ofcom seeks to publish responses on receipt. If your response is non-confidential (in whole or in part), and you would prefer us to publish your response only once the consultation has ended, please tick here.

Name

Signed (if hard copy)

Annex 4

Consultation questions

Question 1 : This executive summary sets out Ofcom's proposals for the release of the digital dividend. Do you agree with these proposals?

Question 2 : Do you have any comments on our analysis of the essential constraints that will apply to the available UHF spectrum?

Question 3 : Do you agree with the more detailed analysis and proposals regarding these technical constraints as set out in Annex 10?

Question 4 : Do you have any comments on Ofcom's assessment of the potential uses of this spectrum? Are there any potential uses which should be considered that are not mentioned in this document?

Question 5 : Do you have any comments on our analysis of the choice between a market-led and an interventionist approach to the release of this spectrum? Do you agree with the analysis of different mechanisms for intervening to remedy potential market failures?

Question 6 : Do you agree with our proposals to continue making available channel 69 for use by low power PMSE devices? Do you agree with our proposal to make some or all of the spectrum available for use on a licence-exempt basis?

Question 7 : Do you agree that there should be transitional protection for professional PMSE users to ensure that they can continue to access interleaved capacity until at least the end of 2012? Do you have any views on the mechanism for providing future access to this spectrum?

Question.8 : Do you consider that additional spectrum from the digital dividend should be reserved for low power applications? If so, please provide as much evidence as possible about the nature of the application and its potential value to society.

Question 9 : Do you consider that it would be desirable to hold back some spectrum from award with a view to its potential use for future innovation? If so, please provide comments on how much spectrum should be held back, and for how long

Question.10 : Do you agree with our proposal that we should package the interleaved spectrum in a way that would be suitable for use by local television services, but not reserve spectrum solely for this use?

Question 11 : Do you agree with our proposal to package the spectrum in a way which does not preclude mobile broadband use, but to take no further action in relation to this use?

Question 12 : Do you agree with our proposal that we should not intervene in the award of this spectrum to reserve spectrum for DTT? Do you agree that we should package the spectrum in a way which is suitable for DTT use?

Question 13 : Do you consider that we have included in our analysis the most material risks in relation to market failure?

Question 14 : Do you agree with our proposal to auction licences for the use of the available UHF spectrum?

Question 15 : Do you agree with Ofcom's proposals as to the timing of any auction? If not, what alternative proposal would you make and why, and what evidence and analysis can you provide in support of your alternative proposal?

Question 16 : Do you have any views on which of the packaging options identified for the cleared spectrum would be most suitable?

Question 17 : Do you have any views on which of the packaging options identified for the interleaved spectrum would be most suitable?

Question 18 : Do you have any views on which of the auction design options would be most suitable?

Question 19 : Do you agree with Ofcom's proposals for the non-technical terms of the licences to be awarded for use of the UHF spectrum?

Question 20: Do you agree with the analysis of the options as set out in this Impact Assessment?

Annex 5

Impact Assessment

Introduction

- A5.1 The analysis presented in this annex represents an impact assessment, as defined in section 7 of the Communications Act 2003 (the Act).
- A5.2 You should send any comments on this impact assessment to us by the closing date for this consultation. We will consider all comments before deciding whether to implement our proposals.
- A5.3 Impact assessments provide a valuable way of assessing different options for regulation and showing why the preferred option was chosen. They form part of best practice policy-making. This is reflected in section 7 of the Act, which means that generally we have to carry out impact assessments where our proposals would be likely to have a significant effect on businesses or the general public, or when there is a major change in Ofcom's activities. However, as a matter of policy Ofcom is committed to carrying out and publishing impact assessments in relation to the great majority of our policy decisions. For further information about our approach to impact assessments, see the guidelines, Better policy-making: Ofcom's approach to impact assessment, which are on our website:
http://www.ofcom.org.uk/consult/policy_making/guidelines.pdf

The citizen and consumer interest

- A5.4 The Digital Dividend Review (DDR) will determine how the spectrum made available by switching off analogue TV broadcasts at digital switchover should be released for new uses. This is an issue of major interest to citizens and consumers, since the spectrum could be used by a wide range of services offering substantial benefits to UK citizens and consumers, and hence value to society.
- A5.5 Our primary duties are to further the interests of citizens in relation to communications matters, and to further the interests of consumers, where appropriate by promoting competition. Ofcom also has a number of other statutory duties relevant to the DDR. These may be summarised as a duty to secure "optimal use" of the radio spectrum and secure certain public policy aims in relation to broadcasting and electronic communications services, while observing the regulatory principle of intervening only where needed.
- A5.6 Allocating spectrum almost always involves trade-offs between different potential uses, because demand for the spectrum almost always exceeds supply. Hence, in the optimal outcome, some uses may not gain access to spectrum, because there are other uses which generate higher value for citizens and consumers, so delivering greater total value to society.
- A5.7 Our stated policy, on which we have previously consulted,⁴⁰ is that generally the market is best placed to make these trade-offs and determine the optimal use of the spectrum. When markets work efficiently, firms are better placed than regulators to make decisions over the best use of spectrum and other resources. Market players

⁴⁰ <http://www.ofcom.org.uk/consult/condocs/sfr/sfr2/>

are likely to have superior information and incentives, which is especially important when the total value of different uses is uncertain.

- A5.8 However, we recognise that there may be circumstances in which the market would not result in the holding and exploitation of spectrum by the users, and for the uses, that generate maximum value to society over time. For the purposes of this project, we refer to this as a 'market failure'.
- A5.9 Therefore, a major part of the project has involved assessing:
- the risk that markets might fail to secure the use of the spectrum that maximises value to society (ie to consumers and citizens);
 - the availability of regulatory remedies to mitigate that risk; and
 - the costs and benefits of those remedies, relative to the costs to society if the spectrum is not used optimally.
- A5.10 In other words, our assessment of the benefits of different options to society, and therefore to citizens and consumers, lies at the heart of our recommendations for the award of the spectrum. This assessment is set out in detail in Section 6 and Annexes 7-8 of this consultation document.

Ofcom's policy objective

- A5.11 Our overarching objective is to design a process for the award of the available UHF spectrum which maximises the value of the spectrum to society.
- A5.12 Uncertainty about the value to society of alternative possible uses of the spectrum, now and in the future, is one of the key factors influencing our decision-making in this award, in two senses. First, the available evidence about the value of alternative uses is inherently limited. Where relevant we have sought to quantify the value of different potential uses of the available spectrum, to ensure that our decisions about packaging and the awards process do not inadvertently exclude potentially viable uses. However this analysis relies on assessments, for example of consumer and citizen demand for services that may not yet exist, which are inherently uncertain and hence can provide only an order of magnitude assessment of the value to society which might be generated. In addition, there are some sources of value which are not readily amenable to quantification, for example the value to society of services providing broader social value. Therefore, the quantitative analysis can only be considered as one input into our assessment of the benefits and costs of different options for awarding the spectrum.
- A5.13 Second, even if we had perfect information about the value of current potential uses, it is highly likely that new, unforeseen, uses for the spectrum will emerge over time, some of which may provide greater value to society than the uses to which the spectrum is initially put. Hence it is not possible or appropriate to seek to design a process that results in the spectrum being awarded now to uses that represent the highest value to society in perpetuity. One of our proposals is that spectrum licences should be tradable, so that if higher value uses for some or all of the available spectrum emerge after the award, there are mechanisms for the initial licence holders to transfer their rights to those new uses. We also suggest that licences should be flexible, containing the minimum necessary technical restrictions on use, to allow the use to change in response to changing circumstances.

Options considered: general

A5.14 At a strategic level, there is a choice between two broad alternatives:

- **Market-led:** Ofcom could choose to impose as few constraints as possible on future use of the spectrum. The minimum constraints would be those necessary to prevent harmful interference to other services in the UK, and to meet the UK’s international obligations.
- **Interventionist:** Ofcom could choose to impose additional constraints in order to exercise more control over the future use of the spectrum. Constraints of this kind could include restrictions that would limit the use of this spectrum to particular services or technologies or to particular categories of user.

A5.15 In general, Ofcom’s preference is for a market-led approach, as set out, and consulted on, in our *Spectrum Framework Review*. However, we have carried out a detailed assessment of the advantages and disadvantages of these options with reference to this particular case. This assessment is set out in Section 6, and summarised in Figure 5.1.

Figure A5.1: Strategic options for the award of the available UHF spectrum

Option	Benefits	Costs
Market-led	<ul style="list-style-type: none"> • Maximum flexibility in use of spectrum, now and in future • Maximum opportunities for new applications and users • Users incentivised to use spectrum as efficiently as possible • Allows other bodies to intervene by funding users that meet public purposes – a more transparent and accountable form of support • Low risk of regulatory failure due to minimal intervention (although note risk of market failure) • Highly transparent process 	<ul style="list-style-type: none"> • Risk that potential uses that are valuable to society but have low commercial value are under-represented in market outcomes – can be mitigated by appropriate public funding and institutional framework • Could increase risk of hoarding or anti-competitive behaviour – depends on how award process is designed
Interventionist	<ul style="list-style-type: none"> • Ensures spectrum available for particular uses eg those that meet public purposes • Prevents risk of market failure (although note risk of regulatory failure) 	<ul style="list-style-type: none"> • Some uses and users would be excluded, even if they represent a high-value use of the spectrum to society • Could prevent future uses getting access to spectrum even if they represent highest value use • Distorted incentives because true cost of spectrum not paid by users • Could reduce efficiency of competition between different service providers and platforms • Reduced scope for experimentation and innovation, except by preferred user • High risk of regulatory failure if preferred use is not, in fact, the use that delivers greatest value to society • Little transparency in process

- A5.16 We have also assessed the likely risk of regulatory failure – one of the principal disadvantages of the interventionist approach. We conclude that an interventionist approach would pose a high risk of regulatory failure in relation to this award, because of the uncertainty about the level of citizen and consumer demand for potential uses of the spectrum in future. Moreover there are other forms of intervention to address potential market failures that do not have such a high risk of regulatory failure. This analysis is also set out in Section 6 and Annex 8.
- A5.17 Our analysis of the producer and consumer value which may be generated from the use of the available UHF spectrum indicated that this could be in the range of £5bn to £10bn (assessed over a twenty-year period from 2008). Given the high degree of uncertainty over the highest-value uses of the spectrum for society and the resulting risk of regulatory failures with an interventionist approach, the costs to society of inappropriate intervention in this award could be of the order of billions of pounds.

The preferred option

- A5.18 In general, we propose to take a market-led approach to the award of the available UHF spectrum. However, where relevant we have also carried out a detailed assessment of possible reasons for intervention with respect to specific uses of the spectrum.
- A5.19 A summary assessment of these arguments for intervention in the award of the available UHF spectrum is contained in Section 6, and a more detailed assessment in Annex 8. In this Annex we provide a brief statement of the alternative approaches that could be taken, and the resulting benefits and costs, for the following potential uses of the available UHF spectrum:
- PMSE for community use;
 - PMSE for professional use;
 - low-power applications;
 - local television;
 - mobile broadband;
 - national digital terrestrial television; and
 - high definition television on digital terrestrial television.
- A5.20 We did not identify market failure concerns warranting detailed assessment in relation to two further potential uses – mobile communications and mobile multimedia.
- A5.21 The approach taken to assessing reasons for intervention was systematic and consistently applied across all services. It is described in Annex 7 to this report. In summary, it consisted of the following steps:
- assessment of the risk that market outcomes do not reflect all elements of value to society offered by a particular use;

- identifying the cause of the loss of value to society (ie the market failure);
- estimating the magnitude of the lost total value to society (ie the severity of the market failure);
- identifying the range of policy options for remedying this situation, and their respective costs, including opportunity cost and regulatory failure; and
- assessing whether the available policy option(s) result in a higher level of overall value to society.

Options considered: service-specific

PMSE for community use

A5.22 Two possible reasons why a market-based award of the available UHF spectrum would result in community PMSE acquiring less spectrum than would be socially optimal have been assessed: the possibility of high transaction costs for community PMSE bidders, and the potential for this use to deliver broader social value that might not be reflected in willingness to pay for spectrum.

A5.23 The discussion set out in Annex 8 concludes that these two potential market failure issues are potentially significant, and the benefits of intervening are likely to be greater than the opportunity cost and regulatory failures which may result.

Figure A5.2 Service-specific options for the award of the available UHF spectrum – PMSE for community use

Option	Benefits	Costs	Assessment of magnitude
Set aside channel 69 for licensed use by PMSE	<ul style="list-style-type: none"> • If licensed we retain the ability to identify users causing interference, where users are licensed, however, the nature of the use means the risk of harmful interference between users is low 	<ul style="list-style-type: none"> • Potentially costly if this option has low value and other uses are excluded, although opportunity cost likely to be relatively low • Licence-exempt use likely to be cheaper and more efficient • Potential uncertainty amongst users and likely high degree of illegal unlicensed use 	<ul style="list-style-type: none"> • Benefits may be relatively low (will depend upon the broader social value generated by this use) • Costs are likely to be low, but are increased by need for licensing • Likely to be positive net benefit but may be small
Set aside channel 69 for use by PMSE but with most or all use on licence-exempt basis (<i>preferred option</i>)	<ul style="list-style-type: none"> • Ensures total value to society of this use is realised • Makes spectrum as widely available as possible at lowest possible cost to users • Certainty for users (subject to resolving exact quantity of licence-exempt spectrum) 	<ul style="list-style-type: none"> • Potentially costly if this option has low value to society and other uses are excluded, although opportunity cost likely to be relatively low (could be as low as tens of millions of pounds) • Significantly reduces the opportunity for future trading and change of use in this spectrum 	<ul style="list-style-type: none"> • Benefits may be relatively low (will depend upon the broader social value generated by this use) • Costs likely to be low • Likely to be positive net benefit but may be small
Auction	<ul style="list-style-type: none"> • Allows for market to 	<ul style="list-style-type: none"> • High transaction costs 	<ul style="list-style-type: none"> • Benefits likely to be low

spectrum in packages constrained to this use	determine means of delivering spectrum for this use	and potential free-rider problem mean true value to society of this use not represented in auction <ul style="list-style-type: none"> • Possible no bid for community PMSE use would emerge • High risk of market failure resulting if PMSE community use is unable to reflect their value in their bid 	<ul style="list-style-type: none"> • Costs could be high, given need for authorisation of users and extra administration as a result • Net effect could be negative
Open auction	<ul style="list-style-type: none"> • Allows other, potentially higher value uses, to compete for access to the spectrum 	<ul style="list-style-type: none"> • High transaction costs and potential free-rider problem mean true value of this use not represented in auction • Likely no bid would emerge • High risk of market failure resulting if PMSE community use is unable to reflect their value in their bid 	<ul style="list-style-type: none"> • Benefits likely to be low • Costs could be high, given need for authorisation of users and extra administration as a result • Net effect could be negative

A5.24 As discussed in detail in Annex 8, and summarised above, we think that making channel 69 licence-exempt is the best option for resolving the market failure concerns identified. The cost of this option is judged to be low and the benefits, whilst still relatively low, are likely to be in excess of the costs and at their highest under this option. The central reason for taking this approach is the risk of market failure due to the high transaction costs for multiple, small, independent users (who do not require co-ordination) participating in an auction-based award process.

PMSE for professional use

A5.25 Four possible reasons why a market-based award of the available UHF spectrum may result in a suboptimal allocation of spectrum for professional PMSE use have been assessed:

- the possibility of high transaction costs for professional PMSE bidders;
- the possibility that the sector may not be able to capture sufficient value from professional PMSE users to fund a bid;
- the potential for this use to deliver broader social value that might not be reflected in the willingness to pay for spectrum; and
- the possibility that users will not be able to make a full transition to a market model before an auction for the spectrum, and that there will be inefficiency as a result of business disruption.

A5.26 The discussion in Annex 8 concludes that intervention was justified due to one of the four potential sources of market failure assessed. The possibility that

professional PMSE users will not be able to make the transition to a market model is potentially significant and the benefits of intervening are likely to be greater than the opportunity cost and regulatory failures which may result. The risks of the other potential market failures were concluded to be relatively low with intervention not being justified. The risk of business disruption is however connected to the diverse nature of the user community, and the need to create new arrangements (or strengthen existing arrangements) to co-ordinate demand.

Figure A5.3 Service-specific options for the award of the available UHF spectrum – PMSE for professional use

Option	Benefits	Costs	Assessment of magnitude
Reserve interleaved spectrum for this use for indefinite future	<ul style="list-style-type: none"> Removes need for co-ordination of demand Ensures full value to society of this use captured Certainty for users 	<ul style="list-style-type: none"> High risk of regulatory failure Possibly high opportunity costs, depending on extent of demand for interleaved spectrum 	<ul style="list-style-type: none"> Benefits may be relatively low Costs likely to be high Net effect likely to be negative
Package interleaved spectrum consistent with use by professional PMSE, but impose no constraints on use	<ul style="list-style-type: none"> Does not exclude other high value uses that are currently known, so opportunity costs likely to be low Maximum flexibility in spectrum use Allows users, not regulator, to decide optimal level of spectrum use, taking into account the cost of that spectrum 	<ul style="list-style-type: none"> Potentially costly for bidders to co-ordinate demand, although cost likely to be relatively low in medium term Risk that transition to a market model requires more time than between now and the expected award of the spectrum 	<ul style="list-style-type: none"> Benefits may be low Costs could be high (if PMSE providers are unable to effectively co-ordinate bid due to transitional problems) Net effect could be negative Risk of business disruption
Make transitional arrangements to secure access to spectrum for PMSE for a limited period (<i>preferred option</i>)	<ul style="list-style-type: none"> Does not exclude other high value to society uses in the long-term, so opportunity costs likely to be low and time-limited Enables orderly transition to new market environment 	<ul style="list-style-type: none"> Potentially costly for bidders to co-ordinate demand, although cost likely to be relatively low 	<ul style="list-style-type: none"> Benefits may be low Costs likely to be low Could be positive net effect although likely to be small

A5.27 As discussed in detail in Section 6 and Annex 8 and summarised above, we think that auctioning the interleaved spectrum in packages consistent with professional PMSE use with a transition period safeguarding access to spectrum for a limited period of time is the best option for resolving the market failure concerns identified. The cost of this option is judged to be low and the benefits are likely to be at their highest under this option.

A5.28 Section 6 and Annex 8 identify that further work is needed on the design of the award process. It may for example be possible to design this in a way that facilitates the long-term co-ordination of demand by the multiple end-users.

Low-power applications and innovation

- A5.29 The potential reason for market failure considered in this document is that a market-based award of the available UHF spectrum may result in a suboptimal allocation to low power uses if there are high transaction costs and free-riding behaviour. The resulting bids for spectrum in an auction may understate the true value of this use.
- A5.30 The discussion set out in Annex 8 concludes that the risks of market failure and the benefits and costs of intervening are not clear at present. If demand is sufficient to make low power applications a high value use, then the benefits of making additional spectrum licence-exempt may outweigh the opportunity cost and regulatory failures that may result.

Figure A5.4 Service-specific options for the award of the available UHF spectrum – low power applications and innovation

Option	Benefits	Costs	Assessment of magnitude
Reserve spectrum for licence-exempt use	<ul style="list-style-type: none"> Ensures full value to society of this use captured Makes spectrum as widely available as possible at lowest possible cost Certainty for potential users 	<ul style="list-style-type: none"> Potentially costly if this option has low value and other uses are excluded Level of demand for this use currently unclear Not clear use needs to be licence-exempt 	<ul style="list-style-type: none"> Benefits are uncertain, but may be low or high depending on value to society of this use Costs likely to be high
Open auction	<ul style="list-style-type: none"> Makes spectrum available for other uses Can retain opportunity to make use licence-exempt if evidence of strong demand for this use emerges 	<ul style="list-style-type: none"> Free rider problem means true value to society may not be reflected, although unclear how significant this is Potentially high opportunity cost if use offers high value to society but is excluded, although this is unlikely 	<ul style="list-style-type: none"> Benefits could be high (if other high value to society uses exist) Costs are uncertain, but may be low or high (depends on extent of free-rider problem and likelihood that this use is excluded)

- A5.31 As discussed in detail in Annex 8 and summarised above, the future demand for low power applications is uncertain. It is not clear that additional spectrum for low power applications would deliver sufficient total value to form part of an optimal solution. However we will review this finding when more evidence is available. We are inviting views through this consultation.

Local television

- A5.32 Three potential market failures relating to providing local TV on the DTT platform have been assessed:
- co-ordination problems resulting in local TV operators being unable to acquire spectrum on a national channel basis even if in aggregate they could bid most for it;
 - the potential for this use to deliver broader social value that might not be reflected in willingness to pay; and

- advertiser-funded business model may result in producer value under-representing total value.

A5.33 The discussion set out in Annex 8 concludes that local TV operators may face co-ordination problems when bidding for national clear channels and that willingness to pay for spectrum may not reflect the broader social value that local TV can deliver, though this broader social value is uncertain. The risk of the potential market failure caused by an advertiser funded business model was concluded to be relatively low, with intervention not being justified.

Figure A5.5 Service-specific options for the award of the available UHF spectrum – local television

Option	Benefits	Costs	Assessment of magnitude
Reserve spectrum for this use	<ul style="list-style-type: none"> • Addresses potential co-ordination problem for operators • Ensures full value to society of this use captured, including broader social value • Certainty for users 	<ul style="list-style-type: none"> • Potentially high opportunity cost • High risk of regulatory failure 	<ul style="list-style-type: none"> • Benefits are uncertain (could be high if value of this use is high) • Costs likely to be high • Net effect uncertain, but likely to be negative
Auction all interleaved spectrum on nationwide basis	<ul style="list-style-type: none"> • Allows maximum opportunity for potential sub-national uses of interleaved spectrum (such as sub-national DTT multiplex, mobile multimedia etc) 	<ul style="list-style-type: none"> • Cost could be high, depending on level of intervention • Local TV operators would face co-ordination problems and threshold risk • Poor response to evidence of demand for interleaved spectrum (much of which is localised) 	<ul style="list-style-type: none"> • Benefits are uncertain • Costs could be high • Net effect uncertain, but likely to be negative
Auction some interleaved spectrum with packages suitable for local TV use (<i>preferred option</i>)	<ul style="list-style-type: none"> • Does not exclude other high value to society uses that are currently known, so opportunity costs low • Opportunity for public bodies to provide funding for services meeting public purposes – more transparent, accountable and effective 	<ul style="list-style-type: none"> • Limited risk of regulatory failure • Requires local TV operators to seek funding from other institutions (RDAs, devolved administrations etc) if business case is not commercially viable (though this requirement may exist whatever method is used to release spectrum) 	<ul style="list-style-type: none"> • Benefits are uncertain (could be high if value of this use is high) • Costs are low • Net effect uncertain, but likely to be positive

A5.34 As discussed in detail in Section 6 and Annex 8 and summarised above, we think that auctioning some packages of the interleaved spectrum that would be suitable for use by local TV operators is the best option for resolving the market failure

concerns identified. The cost of this option is judged to be low and the benefits, while relatively uncertain, are likely to be in excess of the costs.

Mobile broadband

A5.35 The potential reason for market failure considered in this document is that a market-based award of the available UHF spectrum may result in a suboptimal allocation of spectrum for mobile broadband use, because the willingness to pay for spectrum may not reflect the broader social value that this use may be able to deliver.

A5.36 The discussion set out in Annex 8 concludes that any policy intervention to secure universal mobile broadband access goes beyond the scope of the DDR. The potential market failures identified are not likely to require intervention in the design of the spectrum award process.

Figure A5.6 Service-specific options for the award of the available UHF spectrum – mobile broadband

Option	Benefits	Costs	Assessment of magnitude
Reserve spectrum for this use	<ul style="list-style-type: none"> • Certainty for users 	<ul style="list-style-type: none"> • May not be necessary to secure this value to society, resulting in high opportunity cost • May not be sufficient to secure value to society of this use if coverage is not universal 	<ul style="list-style-type: none"> • Benefits likely to be low • Costs likely to be high • Net effect likely to be negative
Do not preclude use of spectrum for mobile broadband, but otherwise no intervention (ie open auction) (<i>preferred option</i>)	<ul style="list-style-type: none"> • Maximises flexibility, transparency and efficiency in use of resources • Opportunity for public bodies to provide funding for services meeting public purposes – more transparent, accountable and effective 	<ul style="list-style-type: none"> • Risk that broader social value would not be captured in auction outcomes, but extent of value and need for UHF spectrum is uncertain 	<ul style="list-style-type: none"> • Benefits uncertain • Costs low • Net effect likely to be positive

A5.37 As discussed in detail in Section 6 and Annex 8 and summarised above, policy intervention to secure universal coverage for mobile broadband is beyond the scope of the DDR. Therefore, we think that no intervention is necessary and that a market-based approach is the best option for the spectrum award process.

National digital terrestrial television

A5.38 Five potential reasons why a market-based award of the available UHF spectrum may result in a suboptimal allocation of spectrum for national DTT use have been assessed:

- co-ordination problems resulting in DTT bidders not representing their true value in an auction;

- capital market failures may result in broadcasters being unable to raise funds to purchase spectrum;
- the broader social value that national DTT can deliver may not be reflected in the willingness to pay for spectrum;
- advertiser-funded business model may result in total value to society not being reflected in willingness to pay for spectrum; and
- effects on the DTT platform may not be taken into account in DTT providers' willingness to pay for spectrum.

A5.39 The discussion set out in Annex 8 concludes that the opportunity costs and regulatory failures that may result from intervening in the award of spectrum are likely to be greater than the benefits.

Figure A5.7 Service-specific options for the award of the available UHF spectrum – national digital terrestrial television

Option	Benefits	Costs	Assessment of magnitude
Reserve spectrum for this use	<ul style="list-style-type: none"> • Ensures full value to society of this use captured • Certainty for these users 	<ul style="list-style-type: none"> • High opportunity cost • Significant reduction in flexibility of use of spectrum • High risk of regulatory failure 	<ul style="list-style-type: none"> • Benefits likely to be low • Costs likely to be very high • Net effect likely to be negative
Open auction (<i>preferred option</i>)	<ul style="list-style-type: none"> • Maximises flexibility, transparency and efficiency in use of resources • Opportunity for public bodies to provide funding for bids meeting public purposes if justified – more transparent and accountable 	<ul style="list-style-type: none"> • Limited, and uncertain, risk of market failure 	<ul style="list-style-type: none"> • Benefits could be significant • Costs likely to be relatively low (depends on risk of regulatory failure) • Net effect uncertain, but could be positive

A5.40 As discussed in detail in Section 6 and Annex 8 and summarised above, we think that the arguments for intervention in the case of SD services on national DTT are not compelling. Therefore, we think that no intervention is justified and that a market-based approach is the best option for the spectrum award process.

High Definition TV on digital terrestrial television

A5.41 Two possible reasons why a market-based award of the available UHF spectrum may result in a suboptimal allocation of spectrum for HDTV on DTT have been assessed:

- the possibility that other platforms move to HD in the future, resulting in a negative impact on consumer and broader social value if sufficient capacity is not made available on the DTT platform. This may not be reflected in operators' ability or willingness to pay for spectrum; and

- the possibility that if the availability of PSB content in HD becomes important for the realisation of broader social value from PSB content. The impact of the availability of additional capacity on the realisation of this value to society may not be adequately reflected in operators' willingness to pay for spectrum.

A5.42 The discussion set out in Annex 8 concludes that the opportunity costs and regulatory failures that may result from intervening in the award of spectrum are likely to be greater than the benefits.

Figure A5.8 Service-specific options for the award of the available UHF spectrum – high definition TV on digital terrestrial television

Option	Benefits	Costs	Assessment of magnitude
Reserve spectrum for this use	<ul style="list-style-type: none"> • Ensures full value to society of this use captured • Certainty for these users 	<ul style="list-style-type: none"> • High opportunity cost • Significant reduction in flexibility of use of spectrum • High risk of regulatory failure 	<ul style="list-style-type: none"> • Benefits uncertain • Costs likely to be very high • Net effect uncertain, and could be negative
Open auction (<i>preferred option</i>)	<ul style="list-style-type: none"> • Maximises flexibility, transparency and efficiency in use of resources • Opportunity for public bodies to fund bids meeting public purposes if justified – more transparent and accountable 	<ul style="list-style-type: none"> • Risk that PSB broadcasters do not act efficiently (or are not permitted to do so) to acquire spectrum if this is the most efficient means of delivering public service objectives. (Options exist for addressing this risk.) 	<ul style="list-style-type: none"> • Benefits uncertain, but could be significant • Costs likely to be low • Net effect uncertain, but likely to be positive

A5.43 As discussed in detail in Section 6 and Annex 8 and summarised above, we think that there is a high opportunity cost and risk of regulatory failure from setting aside spectrum for HDTV on DTT. We believe that a superior alternative would be to ensure that PSBs operate within an institutional and financial framework that provides them with appropriate incentives to act efficiently in pursuit of public service objectives. Therefore, we think that a market-based approach is the best option for the spectrum award process.

Question 20: Do you agree with the analysis of the options as set out in this Impact Assessment?

