OFFICE OF COMMUNICATIONS

Digital Dividend Review

Annexes

Consultation
Annexes

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Annex 6

Ofcom's duties

Ofcom's duties

A6.1 This section provides an overview of the main UK and European legislative provisions relevant to the award of DDR spectrum but is not intended as a comprehensive statement of all Ofcom's duties and functions.

A6.2 The wide variety of different potential uses of DDR spectrum makes it relevant and necessary to consider a range of duties relating to broadcasting, electronic communications services and spectrum management and the interaction between them.

Ofcom's general duties

A6.3 Under section 3(1) of the Communications Act 2003, it is the principal duty of Ofcom in carrying out its functions:

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

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

A6.4 In carrying out this principal duty, Ofcom is required to secure a number of objectives in particular (section 3(2)), and to have regard to such of a number of matters as set out in sections 3(3) and 3(4). Those in section 3(3) must be considered in all cases, whereas those in section 3(4) have to be taken into account only insofar as Ofcom considers them relevant. Some of these objectives and matters are general, such as the desirability of promoting competition, investment and innovation. Others, as outlined below, are more relevant to spectrum or to electronic communications services or to broadcasting, although the division is not always completely clear-cut.

A6.5 There is no hierarchy in the legislation between the two components of the principal duty in section 3(1), or between the objectives in section 3(2), or between the matters in section 3(4).

A6.6 Section 3(3) requires Ofcom to apply certain regulatory principles in all cases. Ofcom has a duty under this section to have regard in all cases to principles under which regulatory activity should be transparent, accountable, proportionate, consistent and targeted only where such action is needed, as well as to any other principles appearing to Ofcom to be best regulatory practice. Ofcom has stated that it will operate with a bias against intervention but with a willingness to intervene firmly, promptly and effectively where required; and, further, that it will intervene where there is a specific statutory duty to work towards a public policy goal that markets alone cannot achieve. If a case for intervention can be made, Ofcom is committed to choosing the least intrusive means.

Ofcom's spectrum duties

A6.7 In carrying out its general duties, Ofcom is required by section 3(2) to secure in particular the optimal use of the electro-magnetic spectrum for wireless telegraphy;

and by section 3(4)(f) to have regard to the different needs and interests of all persons who may wish to make use of the spectrum for wireless telegraphy.

A6.8 In addition, in carrying out its spectrum functions, Ofcom is specifically required by section 154[1] to have regard in particular to:

- the extent to which the spectrum is available for use or further use for wireless telegraphy;
- the demand for use of that spectrum for wireless telegraphy; and
- the demand that is likely to arise in future for the use of that spectrum for wireless telegraphy;
- and to have regard, in particular, to the desirability of promoting;
- the efficient management and use of the spectrum for wireless telegraphy;
- the economic and other benefits that may arise from the use of wireless telegraphy;
- the development of innovative services; and
- competition in the provision of electronic communications services.

A6.9 The management of the UK radio spectrum is also governed by the European Communications Directives, which aim to harmonise the regulation of electronic communications networks and services throughout the European Union. Section 4 of the Communications Act 2003 requires Ofcom when carrying out its spectrum functions to act in accordance with the six "community requirements" set out in that section. The following requirements are relevant to this consultation:

- to promote competition (section 4(3));
- to secure that Ofcom's activities contribute to the development of the European internal market (section 4(4));
- to promote the interests of all persons who are citizens of the European Union (section 4(5));
- to take account of the desirability of Ofcom carrying out its functions in a technology neutral way (section 4(6));
- to encourage to such extent as appropriate the provision of network access and interoperability (section 4(7)); and
- to encourage such compliance with international standards as is necessary for: (a) facilitating service interoperability; and (b) securing freedom of choice for the customers of communications providers (sections 4(9) and (10)).

[1] With effect from 8th February 2007, certain legislation relating to spectrum management, including some provisions of the Communications Act 2003 and the Wireless Telegraphy Acts 1949 and 1998 will be repealed and replaced with a consolidated act, the Wireless Telegraphy Act 2006 (the "2006 Act"). Section 154 Communications Act 2003 will be replaced by section 1 2006 Act. Ofcom's duties under this provision will be unchanged.

Ofcom's electronic communications services duties

A6.10 Requirements of particular relevance to the provision of electronic communications services are included in Ofcom's general duties.

A6.11 Section 3(2) requires Ofcom in carrying out its functions to secure the availability throughout the UK of a wide range of electronic communications services.

A6.12 Ofcom is also required, where it is considered to be relevant in the circumstances, to the desirability of encouraging broadband availability and use throughout the UK (section 4(e)).

Ofcom's broadcasting duties

A6.13 Ofcom's general duties also include requirements germane to broadcasting. Section 3(2) requires Ofcom in carrying out its functions to secure:

- the availability throughout the UK of a wide range of television and radio services which (taken as a whole) are both of high quality and calculated to appeal to a variety of tastes and interests;
- the maintenance of a sufficient plurality of providers of different television and radio services;
- the application, in the case of all television and radio services, of standards that provide adequate protection to members of the public from the inclusion of offensive and harmful material; and
- the application in the case of all television and radio services of standards that provide adequate protection to members of the public from the inclusion of, unfair treatment in programmes and unwarranted infringement of privacy.

A6.14 In addition, Ofcom is required, where it is considered to be relevant in the circumstances to have regard to the desirability of promoting the fulfilment of the purposes of public service television broadcasting in the UK (section 3(4)(a)).

A6.15 Ofcom's duties relevant to spectrum, broadcasting and electronic communications services are summarised in the following figure:

Duty	**Spectrum**	**Broadcasting**	**Electronic communications services**
Principal duty in carrying out functions – section 3(1)	Further interests of: • citizens; and • consumers, where appropriate by promoting competition		

Duty to secure in carrying out principal duty – section 3(2)	Optimal use of spectrum	Availability of a wide range of television and radio services Maintenance of sufficient plurality of providers of broadcast services Adequate protection from offensive and harmful material Adequate protection from unfairness or invasions of privacy	Availability of wide range of electronic communications services
Matters to have regard to in *all* cases –section 3(3)	Regulatory principles of transparency, accountability, proportionality, consistency and acting only where necessary Any other regulatory principles Ofcom considers represent best practice		
Matters to have regard to *where relevant in the circumstances* – section 3(4)	Competition, investment and innovation Opinions of consumers and members of the public Interests of persons in different parts of the UK, different ethnic communities and rural and urban areas Needs of persons with disabilities, the elderly and those on low incomes		

	The different needs and interests of persons wishing to use spectrum	Promoting the fulfilment of the purposes of public service television broadcasting in the UK Standards to guarantee appropriate freedom of expression	Availability and use of broadband
To act in accordance with European principles – section 4	Promote competition Develop European internal market Promote interests of all citizens of the EU Technology neutrality Encourage		

	network access and interoperability Compliance with international standards		
Additional matters to have regard to in carrying out spectrum functions – section 154	Availability of spectrum Current and expected future demand for spectrum Efficient management and use of spectrum Economic and other benefits Innovation and competition Efficiency and sustainable competition and benefits for operators and customers		

Relationship between Ofcom's duties

A6.16 Parliament recognised that Ofcom's duties require it to pursue a range of objectives while taking a variety of matters into consideration and that this was likely to present Ofcom with a need to resolve conflicts between these duties and matters. Ofcom therefore is given a wide measure of discretion in such circumstances within an overall framework set out in the Act. Thus when Ofcom is carrying out any of the functions mentioned in section 4(1)[2] priority must be given to the duty in section 4(2) (duty to fulfil Community obligations) over the general duties in section 3 (section 3(6)); and the section 3 duties take precedence over the section 154 spectrum duties (section 154(4)). Subject to that, however, section 3(7) gives Ofcom a broad discretion to resolve conflicts between its general duties in the manner it thinks best in the circumstances. The "general duties" referred to here include the principal duty under section 3(1), the duty to secure the objectives set out in section 3(2) and the duty to have regard to the matters in section 3(4).

A6.17 Where Ofcom resolves a conflict in an important case, it must publish a statement setting out the nature of the conflict, how Ofcom decided to resolve it and the reasons for resolving it in that manner. An important case is one that involves a

[2] The functions mentioned in section 4(1) are functions relating to regulation of electronic communications networks and services, management of the radio spectrum, resolution of disputes, and provision of information.

major change in Ofcom's activities, that is likely to have a significant impact on business or the general public or that Ofcom considers to be of unusual importance.

A6.18 In addition, Ofcom must comply with any direction issued by the Secretary of State relating to spectrum management (see in particular sections 5 and 156 of the 2003 Act[3]).

Legal background relevant to wireless telegraphy licensing

Granting wireless telegraphy licences

A6.19 Ofcom's legal power to grant wireless telegraphy licences is set out in the Wireless Telegraphy Act of 1949 (the "1949 Act"[4]). Section 1(1) of the 1949 Act[5] makes it an offence for any person to establish or use any station for wireless telegraphy or to install or use any apparatus for wireless telegraphy except under and in accordance with a licence granted by Ofcom under that section (a wireless telegraphy licence).

A6.20 Section 1(2) of the 1949 Act[6] gives Ofcom the power to grant wireless telegraphy licences subject to such terms as Ofcom think fit.

A6.21 However, Ofcom's broad discretion in relation to the terms that can be imposed in a wireless telegraphy licence is subject to the rule that Ofcom must impose only those terms that it is satisfied are objectively justifiable in relation to the networks and services to which they relate, not unduly discriminatory, and proportionate and transparent as to what they are intended to achieve (section 1D(9))[7].

Providing for an auction of wireless telegraphy licences

A6.22 Under Article 5(2) of the Directive on the authorisation of electronic communications networks and services 2002/20/EC (the "Authorisation Directive"), when granting rights of use of radio frequencies (wireless telegraphy licences in the UK context), Member States must do so through open, transparent and non-discriminatory procedures.

A6.23 Under Article 7(3) of the Authorisation Directive where the number of rights of use of radio frequencies needs to be limited, Member States' selection criteria must be objective, transparent, non-discriminatory and proportionate. (Section 164 of the 2003 Act[8] requires Ofcom to make an order setting out the criteria).

A6.24 Within that context, Ofcom has power under section 3 of the Wireless Telegraphy Act 1998[9] (the "1998 Act") (having regard to the desirability of promoting the optimal

[3] With effect from 8th February 2007, s. 156 Communications Act 2003 will be repealed and replaced with s.5 2006 Act. Ofcom's duties under this provision will be unchanged.
[4] See footnote 1 above.
[5] With effect from 8th February 2007, s.1(1) 1949 Act will be repealed and replaced with s.8 2006 Act. Ofcom's powers and duties under this provision will be unchanged.
[6] With effect from 8th February 2007, s.1(2) 1949 Act will be repealed and replaced by s.9(1) 2006 Act. Ofcom's powers under this provision will be unchanged.
[7] With effect from 8th February 2007, s.1D(9) 1949 Act will be repealed and replaced by s.9(7) 2006 Act. Ofcom's duties under this provision will be unchanged.
[8] With effect from 8th February 2007, s.164 2003 Act will be repealed and replaced with s.29 2006 Act. Ofcom's duties under this provision will be unchanged.
[9] With effect from 8th February 2007, s.3 1998 Act will be replaced with s.14 2006 Act. Ofcom's power under this provision will be unchanged.

use of the electro-magnetic spectrum) to make regulations providing that applications for the grant of wireless telegraphy licences must be made in accordance with a procedure which involves the applicants making bids for licences (for example an auction).

A6.25 Ofcom has broad powers in section 3(3) 1998 Act[10] to make provision in regulations for the form of the licences and the auction bidding procedure.

Charging fees for wireless telegraphy licences

A6.26 Ofcom also has power, under section 1 of the 1998 Act[11], to prescribe in regulations fees that are payable in respect of wireless telegraphy licences or a grant of spectrum access. Under section 2[12] Ofcom may prescribe sums which are greater than necessary for the purpose of recovering costs incurred in connection with functions relating to the management of the radio spectrum, if it thinks fit in the light (in particular) of the matters to which they are required to have regard under section 154 of the 2003 Act[13].

A6.27 The fees for most wireless telegraphy licences are set out in specific regulations (including those fees which are set by Ofcom in order to incentivise the use of the spectrum). The current regulations are the Wireless Telegraphy (Licence Charges) Regulations 2005 (SI 2005/1378).

A6.28 Under Article 13 of the Authorisation Directive, any fees imposed for rights of use of radio frequencies shall reflect the need to ensure the optimal use of the resources. Such fees must be objectively justifiable, transparent, non-discriminatory and proportionate in relation to their intended purpose (and take into account the objectives set out in Article 8 (Policy objectives and regulatory principles) of the Directive on a common framework for electronic communications networks and services 2002/21/EC14 (the "Framework Directive")).

Legal background relevant to broadcast licensing

A6.29 Under section 13 of the Broadcasting Act 1990 it is an offence to provide a relevant regulated television service without being authorised to do so under a licence granted by Ofcom under the Broadcasting Act 1990 or the Broadcasting Act 1996. A relevant regulated television service means a service falling, in pursuance of section 211(1) of the Communications Act 2003, to be regulated by Ofcom, other than a television multiplex service. Television multiplex services only have to be licensed under the Broadcasting Act 1996 if this is required by a provision of a wireless telegraphy licence.[15]

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[10] With effect from 8th February 2007, s.3(3) 1998 Act will be repealed and replaced with s.14(2) and (3) 2006 Act. Ofcom's powers under this provision will be unchanged.
[11] With effect from 8th February 2007, s.1 1998 Act will be repealed and replaced with s.12 2006 Act as regards licences and s.21 2006 Act as regards spectrum access. Ofcom's powers under these provisions will be unchanged.
[12] With effect from 8th February 2007, s.2 1998 Act will be repealed and replaced with s.13 2006 Act as regards licences and s.22 2006 Act as regards spectrum access. Ofcom's powers under these provisions will be unchanged.
[13] With effect from 8th February 2007, s.154 2003 Act will be repealed and replaced with s.6 2006 Act. Ofcom's duties under this provision will be unchanged.
[14] The Directive of the European Parliament and the Council on a common regulatory framework for electronic communications networks and services (2002/21/EC)
[15] See further section 241 of the Communications Act 2003.

A6.30 In relation to radio services, section 97 of the Broadcasting Act 1990 prohibits the provision of a relevant regulated radio service without a licence under the Broadcasting Act 1990 or the Broadcasting Act 1996. A relevant regulated radio service means a service falling to be regulated by Ofcom under section 245 of the Communications Act 2003, other than a radio multiplex service. Radio multiplex services only have to be licensed under the Broadcasting Act 1996 if this is required by a provision of a wireless telegraphy licence.[16]

Regulatory impact assessments (RIAs)

A6.31 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.

A6.32 In accordance with section 7 of the Act, Ofcom has set out an RIA in annex 5 of this consultation.

[16] See further section 258 of the Communications Act.

Annex 7

Capturing consumer and citizen interests

Setting the scene

A7.1 Spectrum allocation decisions will almost always involve trade-offs between different potential uses. This is because spectrum is a resource which is scarce; a resource for which demand is in excess of supply. When the market decides on the use of spectrum this trade-off is made by the market, as competing uses reflect the value their use of spectrum generates through the price they are willing to pay. It is this trade-off of the value which can be generated by different uses which allows a market to arrive at an allocation of spectrum that maximises the value to society. Therefore, if we are to take a generally market-led approach to the release of spectrum, the importance of this trade-off in arriving at an outcome that maximises value to society raises two important questions for Ofcom's policy making:

- first, are there situations in which the trade-offs made by the market do not reflect all the sources of value to society? and
- second, if there are such situations, what is an appropriate policy response?

A7.2 The framework used for making policy decisions in the DDR has been developed to address these two questions. The remainder of this Annex documents the work which underlies this framework and explains how it addresses these two important questions. The framework is then applied in the next Annex to consider the specific issues that have arisen in the context of the digital dividend spectrum.

A7.3 These are questions that do not arise solely in relation to the use of spectrum, but in relation to the use of almost all resources by society – such as land, labour and capital. It is important to bear in mind this wider context when considering the issues in relation to spectrum especially as there are almost always trade-offs between the use of any unit of spectrum and other inputs to deliver outputs that are valued by society.

A7.4 Section 5 of this consultation document sets out how Ofcom's duties have provided the base for its decision making framework in the DDR. Ofcom's primary duties to further the interests of citizens and consumers are at the heart of this framework. It is within the context of these primary duties that Ofcom's approach to spectrum should be viewed.

A7.5 Ofcom's spectrum strategy is based upon its duty to secure the optimal use of the radio spectrum. From the perspective of our objective in the DDR, which is to maximise the value to society from the use of the spectrum, the optimal use of the radio spectrum is the use of spectrum which maximises the value generated for society and hence which maximises value to citizens and consumers.

A7.6 As set out in the Spectrum Framework Review, it is Ofcom's view that the optimal use of the radio spectrum is generally secured by allowing the market to decide how spectrum should be used. This is based upon the belief that, in the absence of barriers which may prevent a market from working efficiently, users are better placed than regulators to make informed decisions over the best use of spectrum. This is because, when markets work efficiently, the incentives of users will be

aligned with the outcomes which are best for society.[17] Therefore, trade-offs made by users when deciding how to invest their resources will better reflect the value to society of using those resources than decisions made by regulators. This is because markets provide users with information, for example about the opportunity costs of spectrum, and with incentives to accurately reveal and respond to this information, neither of which a regulator would have access to. This helps users to arrive at the outcome which maximise the total value generated from the use of a resource.

A7.7 For an optimal outcome to be achieved it is important for Ofcom to assess whether there are barriers which would prevent a market from working efficiently (such barriers are often referred to as "market failures"). Therefore, the conceptual framework which Ofcom has developed for assessing policy options in relation to the DDR is concerned with assessing whether there are barriers which would prevent a market from maximising the value which is generated for society. In order for this assessment to be made it is important to identify the following:

- what are the key elements of value to society?
- how are these key elements of value represented in market outcomes? and
- if there are situations in which some of these elements of value to society are not fully reflected in a market outcome, how could this be addressed in order to arrive at an outcome in which the overall value to society is maximised?

Citizens, consumers and value to society

A7.8 As set out above, one of the key questions which Ofcom has addressed in developing its conceptual framework is how the key elements of value to society can be captured. The analysis presented in the following section sets out our response to this question.

Consumer and citizen interests

A7.9 We have developed a categorisation of consumer and citizen interests in order to ensure that our analysis fully captures all aspects of consumer and citizen interest. Our starting point has been the work which Ofcom has already undertaken in this area. This is exemplified by the approach proposed in the consultation on Ofcom's Consumer Policy and in the work completed for the PSB review.

A7.10 In the Consumer Policy consultation we set out that there is a close relationship between consumer and citizen interests. This is partly because as individuals we act both as citizens and consumers, but also because the interests under these two headings frequently overlap. However, after taking this into account we identified the following definitions of consumer and citizen interests:

A7.11 "Consumer interests arise following the establishment of a market, in which individual consumers make decisions about the acquisition and/or use of goods and services, which are provided by suppliers. The establishment of a market creates options for consumers, about whether to purchase or use particular goods and services, and if so in what quantity or with what frequency."

[17] As discussed later in this section, when markets work efficiently the ranking of willingness to pay for spectrum across uses should be aligned with the ranking of these services from the perspective of the total value to society.

A7.12 “As citizens, on the other hand, we have a shared, collective interest in a range of issues which are beyond the market, but which also have a major influence on our lives. Within the communications sector, examples include our interest in the universal availability of basic communications services, and in access to a diversity of opinions about news and current affairs. Issues such as these affect us collectively, rather than purely through a market mechanism as individuals.”

A7.13 As identified in the Consumer Policy consultation, our interests as consumers and citizens as defined above may at times be in conflict. An example of this would be that our private consumer interest in driving cars may conflict with our interest as citizens in tackling global warming. However, in other situations, there may be significant overlap between the interest as a citizen or a consumer. Policies such as Universal Service Obligations in telecommunications and Public Service Broadcasting, for example, speak directly to the rights and benefits of citizenship but also involve impacts upon markets, which have implications for the consumer.

A7.14 Based upon the distinction between consumer and citizen interests set out above the Consumer Policy consultation sets out the following objectives for consumer- and citizen-related policy:

A7.15 “Consumer policy is concerned with ensuring that markets operate in a manner which most effectively serves consumer interests. The purpose of consumer policy is to facilitate the operation of markets, to remove barriers and correct market failures which might otherwise prevent them delivering what consumers want.”

A7.16 “Citizen-related policy is concerned with changing the outcome delivered by the market in order to meet a broader social, cultural or economic objective or interest.”

A7.17 In the PSB review we identified a similar distinction between consumer-focused and citizen-focused objectives of PSB. Consumer-focused objectives relate to the efficient working of the market to deliver what consumers want. Citizen-focused objectives relate to wider social objectives, which incorporate products or services which as citizens we want to be available to as many people as possible, but which would be underprovided by the market.

A7.18 To clarify the areas of overlap and distinctiveness between consumer and citizen interests, we have developed the following three categories, which are shown in Figure 7.1:

- interests with respect to **access** to the market. These include a range of interests which relate both to our direct access to markets as consumers and our interests as citizens in access for all to markets which bring broader social benefits. Such interests include the existence of a wide range of services (which is a consumer interest) and the rights of all consumers to certain key services, for example ensuring accessibility for disabled people (which is both a consumer and citizen interest);

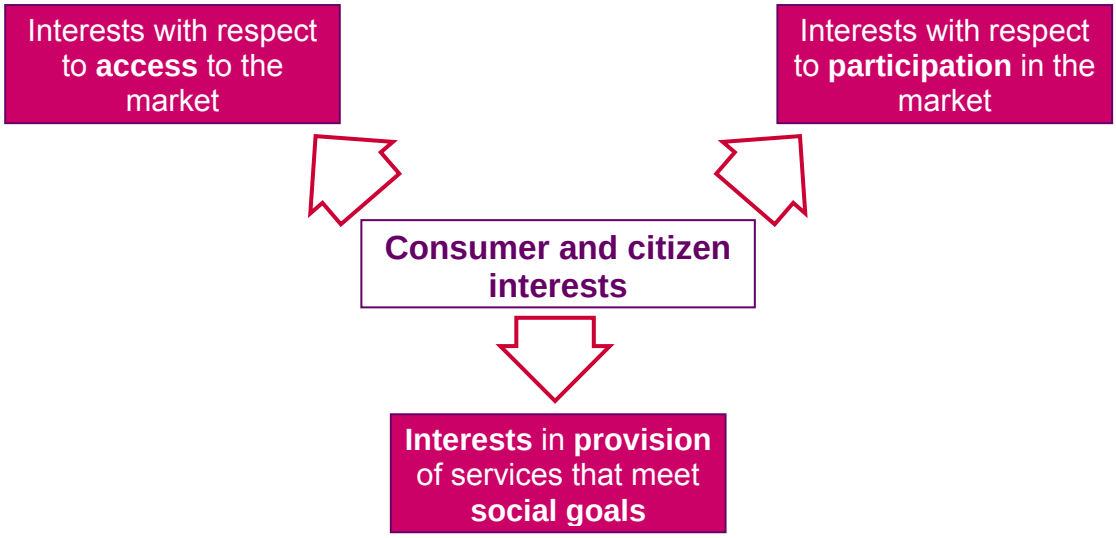
- interests with respect to **participation** in the market (ie interests which arise from the use of a market rather than from the ability to access it). These include interests in fair practices, low prices, quality and choice. These interests all relate directly to consumers as they flow from direct participation in a market; and

- interests in **provision of services that meet social goals**. These include interests we hold as citizens, which go beyond consumer interests. They relate to the provision of services (ie to the content or quality of services) and could

include, for example, provision of services which foster social inclusion, quality of life, strong communities, cultural understanding, citizenship, protection of the environment and avoidance of social harm.

A7.19 We believe that this categorisation of consumer and citizen interests is useful as it allows the areas where there is likely to be overlap between consumer and citizen interests to be separated out from those interests which are relevant to consumers and citizens separately. These interests are shown in the diagram below.

Figure 7.1



Consumer value and broader social value

A7.20 Consumer and citizen interests represent issues which consumers and citizens have preferences over. In other words they are issues from which consumers and citizens derive either benefit or disbenefit. Therefore, we can think of these interests as translating into a degree of preference which can in turn be thought of as indicating value. The greater a preference a consumer or citizen has, the higher the potential value accruing to individuals (both as consumers and citizens) as a result of that good or service being provided.

A7.21 We have identified the following as elements of value which are relevant respectively to consumers and citizens:

- consumer value – this includes the value consumers derive when they engage in markets by making use of products or services. Hence, this includes value which is derived from serving *consumer* interests in relation to both:
  - participation in markets; and
  - access to markets.
- broader social value – this includes value which we derive as citizens from products or services. This includes value which is derived from serving *citizen* interests in respect of:
  - provision of services which meet social goals; and

- access to markets.

A7.22 Therefore, two of the three categories of consumer and citizen interests align fully with one or other source of value. The other category - access to markets – is the area of overlap and so is sub-divided between consumer and broader social value. These are largely situations in which access is provided to services which are considered to bring broader social value. The broader social value should include the value we derive as citizens from this service being provided, whilst the consumer value should capture the impact of any extension of access to the market for consumers (for example, for the consumer value generated by extending coverage).

A7.23 Broader social value potentially incorporates a very wide range of different social goals in which we have an interest as citizens. In order to ensure that we capture value to citizens which may be affected by the release of the available UHF spectrum (as well as consumer sources of value) we have developed the disaggregation of broader social value set out below. This has been identified based on a review of public policy aims to deliver social goals through access to, or provision of, services which may make use of the available UHF spectrum. Our review has considered the following publications: the Communications Act, Ofcom's PSB review, BBC building public value, i2010 agenda, and the Cabinet Office report on "Connecting the UK: the digital strategy". Additionally, we commissioned deliberative market research to test whether our categories of broader social value fully represented the sources of value to society which members of the public (as citizens) expected to result from the potential uses of the available UHF spectrum.

A7.24 This work identified the following elements of broader social value:

- access and inclusion – for example value derived from universal access and facilitating access to public services;
- quality of life – for example value derived from providing access to services which promote quality of life, perhaps by helping to support or promote work-life balance or family life;
- belonging to a community – for example value derived from allowing people with similar interests to communicate or from participating in your local community;
- educated citizens – for example value derived from services with educational content or child-oriented services;
- cultural understanding – for example value derived from services which reflect and strengthen cultural identities or promote diversity and understanding of other cultures;
- informed democracy – for example value from services which provide information which facilitates democratic debate; and
- social bads – this can include negative value derived under any of the headings set out above.

What is captured by welfare analysis?

A7.25 Welfare analysis is the approach used in economics to assess the net benefits which are generated for society from the use of resources such as spectrum. We

have compared the sources of value usually taken into account in such an analysis to the sources of value set out above, to ensure that our assessment of the value to society derived from the use of available UHF spectrum is sufficiently broad to fully capture all of the benefits to consumers and citizens.

A7.26 The starting point of welfare analysis is the measurement of the value generated for producers and consumers:

- producer value, which is often referred to as producer surplus, consists of the benefits producers gain from their activities as measured by the profits they earn (beyond the minimum required to attract investment); and

- consumer value, which is often referred to as consumer surplus, consists of the benefits accruing to consumers from their use of a product or service as measured by the excess of a consumer's willingness to pay for a product or service over the price actually paid.

A7.27 Welfare analysis includes an assessment of the net benefits which producers directly gain from their production of a good or service, the net benefits which consumers directly gain from their use of a good or service, and any costs or benefits which indirectly affect other producers or consumers (these are commonly referred to as externalities). Externalities can be caused by a range of different factors, and can have both positive and negative effects. An example of an externality which commonly affects consumers is the positive benefits which accrue to existing subscribers to a network as additional subscribers decide to join; this is commonly called a network externality. These benefits can result from there being more subscribers for you to interact with (ie more people you can call) or from increasing content availability as the increase in the general level of demand acts as a spur to the development of additional content (ie more content is made for mobile TV devices which all subscribers can access).

A7.28 The inclusion of these indirect effects means that welfare analysis also captures any other costs or benefits over which individuals are able to express preferences. These can include values that individuals derive as consumers (eg network externalities) but also values which derive to citizens in the form of broader social value. For example, in the field of environmental economics welfare analysis is used to capture the value derived by members of society from the presence of environmental "goods" and "bads" (eg the endangerment of animal species)[18]. Additionally, economic analysis of broadcasting markets has commonly captured the citizenship benefits (and dis-benefits) of broadcasting under a framework of externalities.[19] [20]

A7.29 Therefore, welfare analysis can capture citizen preferences through the analysis of externalities, which reflects the broader social value that individuals derive as citizens from the provision of a good or service even if they do not consume it

[18] For example, see discussion in Kontoleon, Macory, and Swanson, 2002, "Individual preference-based values and environmental decision making: should valuation have its day in court?", Research in Law and Economics, V20, pages 179-216.
[19] For example, Armstrong and Weeds (2004), "Public Service Broadcasting in the Digital World", The Economic Review of Broadcasting Markets: Evolving Technology and the Challenges for Policy, Paul Seabright and Jurgen von Hagen (eds.). Cambridge University Press.
[20] Our review of the academic literature also identified that this approach has been applied to capturing broader preferences of citizens within a framework of externalities and welfare analysis in analysis of issues such of the protection of cultural heritage and societal externalities (such as the impact of urbanisation on rural communities).

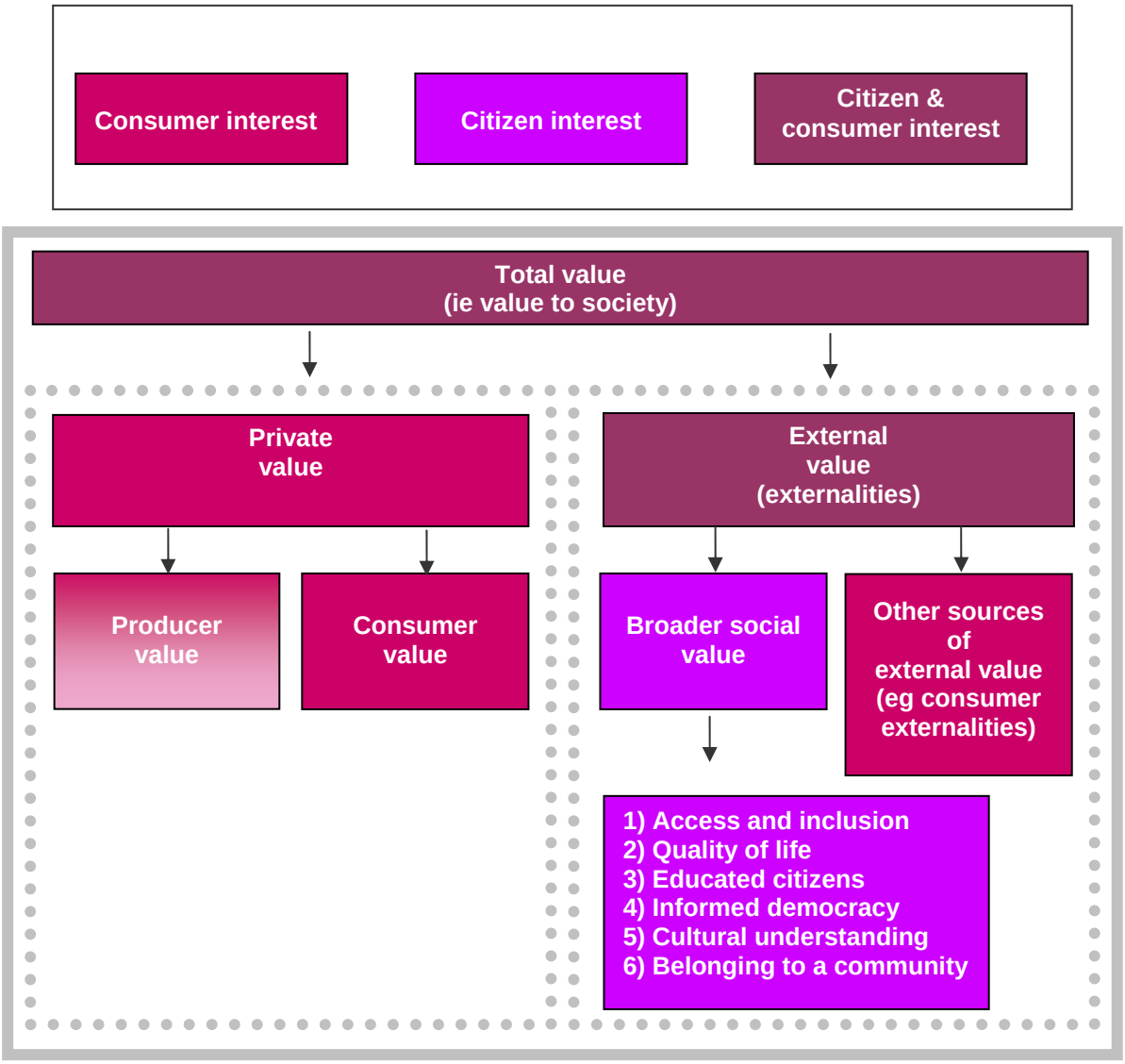
directly. In the field of environmental economics these are referred to as "non-use goods". As these sources of value are not directly driven by an individual's consumption of a good or service they would normally be thought of as being external effects or externalities. Therefore, where individuals are able to express a preference[21] over the use of resources to achieve social goals (eg universal access to a particular service) then the broader value to society of meeting these social goals can be captured within welfare analysis.

A7.30 Therefore we believe that broader social values, such as access and inclusion, belonging to a community, informed democracy, and the other elements set out in paragraph 7.24 above can be captured within a framework of welfare analysis. The treatment of these sources of value would be analytically similar to the treatment of externalities and, in particular "non-use goods" as mentioned above. That is, the preferences of citizens over the provision of a service to other members of society that meets social goals would be captured separately from their individual preferences over their own consumption of such goods. Therefore, as these values are not driven directly by an individual's consumption decision, they would fit under the heading of externalities.

A7.31 The following figure shows how the inclusion of these categories of broader social value within a framework of value results in all sources of value to society reflected in individual preferences being captured, and hence, in the full value derived from serving consumer and citizen interests being represented in an analysis of the impact of resource allocation on society.

[21] A preference over the use of resources to achieve a social goal would be reflected in an individual's willingness to pay (or a willingness to forgo alternative benefits) for the service to be provided for the good of society.

Figure 7.2 Framework for assessing value to society [22]



A7.32 We use the term "total value" to refer to assessment of value which incorporates broader social values as well as sources of value which derive to consumer and producers. Therefore, whenever we use the term "total value" we consider this to reflect the value to society, as total value fully reflects consumers' and citizens' interests.

Measuring broader social value

A7.33 The work in the field of environmental economics has identified a number of different approaches which could be used to assess the magnitude of broader social values, when analysed in this way:

[22] 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.

- assessment of willingness to pay / of willingness to forgo: these involve using stated preference techniques to assess citizen preferences and values. These techniques involve using market research techniques (such as contingent valuation, choice experiments and contingent rankings) to elicit responses from citizens to trade-offs. These techniques can be used to derive an estimate for broader social values by asking citizens to express preferences over the supply of goods or services from the perspective of society. However, to do so they involve the construction of a hypothetical market, which can raise questions about whether responses of citizens/consumers in these exercises are consistent with the way they would behave in reality;

- pricing techniques: these involve inferring citizen preferences from the behaviour of citizens (for example, from charitable donations or from the purchases which are driven by societal rather than pure individual gain, such as purchasing ethical products). These techniques are based on real market data and so are not subject to the hypothetical market problems of the stated preference assessment of willingness to pay. However, in many cases these techniques will provide an inadequate assessment of citizen value, because they will not cover all relevant issues and may understate the true level of citizen value;

- deliberative approaches/citizen juries: these involve the use of focus group-type discussions of issues to identify the preferences of the group over various trade-offs that society might have to make. These discussions often involve the provision of information to participants to help them to make informed decisions. These techniques have the advantage of ensuring that respondents are making decisions based on more information than would normally be available to them. However, as they usually involve the identification of a majority view they may fail to include minority interests;

- expert-based approaches: these involve expert panels making informed judgements about options for society. They are based least directly on citizen preferences, but make most use of the in-depth knowledge of experts over the various trade-offs which may need to be made; and

- political processes: this involves the voting in or out of political parties based on the social goals they claim they wish to secure and their tax and spending decisions. This technique is based on citizen preferences as real trade-offs are made by political parties. However in many cases this technique may not produce an accurate assessment of citizen value as there are a number of other important factors influencing voting behaviour. Furthermore, the interests of minority groups may not be captured.

A7.34 These different approaches all have pros and cons[23], and it will generally be preferable to employ a range of different techniques in order to inform decisions based on broader social values. Some of these techniques may allow the quantification of broader social value whilst others will only involve a qualitative assessment of the potential magnitude of this value.

A7.35 As part of the DDR we have used three of the techniques detailed above.

[23] Further discussion of these techniques can be found in Kontoleon, Macory, and Swanson, 2002, "Individual preference-based values and environmental decision making: should valuation have its day in court?", Research in Law and Economics, V20, pages 179-216.

- market research which has assessed willingness to pay, including the trade-off between uses based upon their importance to society;

- deliberative market research to assess the preferences of citizens over different possible uses of the available UHF spectrum; and

- an assessment of the broader social value which could be generated from the potential uses of the spectrum from an academic expert in this field (Dr Damian Tambini, Senior Lecturer at the Department of Media and Communications, London School of Economics).

A7.36 The results of this work are discussed in the market research report published alongside this document which is available at http://www.ofcom.org.uk/consult/condocs/ddr/mktresearch/ and in our consultants report which is available at http://www.ofcom.org.uk/consult/condocs/ddr/report_analysys/

Summary

A7.37 One of the key questions which we have addressed in developing our conceptual framework is how all of the key elements of value to society can be captured.

A7.38 We identify two sources of value which capture the value which is derived from serving consumer and citizen interests respectively: consumer value and broader social value.

A7.39 Both consumer value and broader social value would be captured within the framework of welfare analysis, based on individual preferences. Broader social values are captured both conceptually and in practice by the inclusion of citizen preferences over the provision of services to others. Therefore, the total value framework that we use in the DDR captures all key elements of value to society.

Trade-offs, market failure and regulatory failure

A7.40 Taking into account the concept of total value (ie value to society) discussed in the previous section, how are the elements of value taken into account in market outcomes?

The trade-off

A7.41 The digital dividend spectrum is scarce because the demand exceeds the available supply – not all of the uses that would like to make use of this valuable spectrum can be accommodated. This means that some uses which would provide value to consumers and citizens will not be able to obtain the spectrum that they want. A trade-off between uses must, therefore, be made, because more spectrum for one use means that less spectrum is available for another. The total value of the highest value alternative use (a use that is displaced) is the opportunity cost, because it is the cost (or lost total value) to society caused by that use being denied the opportunity to make use of the spectrum.

A7.42 An efficient trade-off occurs where total value, and hence value to society, is maximised. That is, the value to society is maximised where an increase in spectrum for any use would result in a smaller increase in total value than the opportunity cost (the total value lost from the displaced uses).

Market failure

A7.43 How are the elements of value taken into account in market outcomes? Under a market-led approach the trade-offs between uses and users are made via the auction (and subsequently via secondary market mechanisms, such as trading). To obtain a larger amount of spectrum, the prospective suppliers of a use must make a higher bid than competing bidders, ie the amount that they are willing to pay for spectrum is larger than the amount that prospective suppliers of the displaced use are willing to pay. The trade-off will be transparent with a market-led approach - the willingness to pay for spectrum of the losing bidders will be known. If the bidders' willingness to pay for spectrum reflects total value, the market-led approach will result in an efficient outcome in which the value to society is maximised. More precisely, the requirement is that the ranking of the willingness to pay for spectrum of the different competing uses is the same as the ranking of total value, ie the highest bid at an auction is for the use that yields the highest value for society.[24] We use the phrase "market failure" to denote the circumstances in which this does not occur and the market-led approach fails to maximise total value, and hence value to society.

A7.44 There is the possibility of market failure because bids at an auction generally reflect only one element of total value, namely the producer value or profit that the supplier expects to earn. As shown in Figure 7.2 above, the other elements of total value are (private) consumer value, broader social value and other sources of external value. But, as noted in the previous paragraph, what matters is the correlation between profitability and total value - the market-led approach will be efficient, if the most profitable use is also the use with the highest total value. There are good reasons to expect a correlation between relative profit and total value, and hence value to society. For example, uses that are more highly valued by consumers are also likely to be more profitable, as are those that can be produced more efficiently.

A7.45 As regards external value, it is not the existence of external value for a use, such as broader social value, in itself that leads to market failure. A number of the competing uses may yield external as well as private value, so the market-led approach only suffers from market failure if the differences in external value between uses are sufficiently large to create a misalignment between the ranking of the willingness to pay for spectrum and total value. Furthermore, if it is considered that a service will generate especially high external value, appropriate action by public sector institutions can allow bids for spectrum at an auction to be more closely aligned with total value (and hence value to society), and thus market failure avoided. This is no different in principle from the decisions that public sector institutions have to make about the acquisition of other scarce resources – whether specialist labour that is in short supply, or land and buildings, or other capital assets.

A7.46 We recognise, however, that careful consideration of possible market failures is important, especially given the unusually diverse range of potential uses for the digital dividend spectrum. Moreover, in the past successive Governments have used spectrum as a policy instrument – that is they have allocated spectrum to particular users as a means of funding and otherwise securing the delivery of public policy goals. Given that this has happened in the past it is important to consider how exactly to transition to a market-based regime. Section 6 and Annex 8 set out a

[24] This ranking assessment is not only relevant to the initial award, a market failure would also occur if, in the future, the ranking of willingness to pay for spectrum via secondary markets across uses and users does not coincide with their total value ranking.

detailed analysis of possible market failures in the context of the Digital Dividend Review.

Regulatory failure

A7.47 Under an interventionist approach it is the regulator that makes the trade-off between one use and another. It requires the regulator to have a large amount of accurate information about the total value of the competing uses and the efficient amount of spectrum that each requires, and then to choose the highest-value combination. We use the phrase "regulatory failure" to refer to the circumstances in which the interventionist approach fails to maximise total value, and hence value to society. This can be due to a failure to achieve the desired effect, for example, when the benefits of intervening do not turn out to be as high as expected. Or regulatory failure can occur when there are unintended adverse consequences of intervention, either in other markets or over time.

A7.48 To make the efficient trade-off, the regulator needs to know not just which of the uses has initially the highest total value, but also how this may change in the future, including allowance for the development of new technologies and uses. Whereas a market-led approach utilises information from those who are likely to be using the spectrum and supplying the services, and provides incentives for them to reflect it accurately, the interventionist approach relies on the regulator's information and judgement. Furthermore there is a lack of transparency about opportunity costs, because of the absence of a mechanism to reveal them, which increases the difficulty for the regulator to make the choices that maximise total value.

A7.49 The conditions required for the regulator to make an efficient trade-off that maximises total value (and hence value to society) are extremely demanding. As discussed in Section 6, they are less likely to be satisfied when there is a wide range of competing uses, more uncertainty, and the degree of inflexibility introduced by restrictions on use are greater.

A7.50 Spectrum is an input into the supply of a wide range of uses or services supplied to consumers and citizens. An additional concern about an interventionist approach to spectrum allocation is that it is likely to distort choice of inputs, because it does not provide incentives for spectrum users to economise on their use of spectrum and to choose more efficient alternative inputs.

Approach to achieving efficient trade-offs

A7.51 We consider, in general, that a well-designed market-led approach offers good prospects for the most efficient uses and users to obtain spectrum – that is, the ones that maximise the total value (and hence value to society). This is the assessment of value which includes broader social value and other external value as well as private value to consumers and producers. If this does not occur, there is a market failure. There are possible reasons why market failure can be present, as we discuss in detail in Annex 8.

A7.52 However, the relevant question is not whether a market-led approach is perfectly efficient (ie the absence of any market failure), but whether it is better than the alternative of an interventionist approach. We can characterise the strategic choice between a market-led approach and an interventionist approach as the question whether market failure or regulatory failure is likely to be larger. We take the view that a market-led approach is generally to be preferred for a number of reasons discussed above and in Section 6:

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

- it avoids distorting the efficient use of inputs, both economising on spectrum and choosing alternative inputs if more efficient;

- there is greater transparency of the opportunity cost which increases the chances of efficient choices being made that maximise total value;[25] and

- it allows greater flexibility in the use of spectrum, including over time as circumstances change, such as in response to advances in technology.

A7.53 Specifically for the available UHF spectrum we have carefully assessed whether a market-led approach is to be preferred. In Section 6 and Annex 8 we consider the questions of market failure, opportunity cost and regulatory failure at a detailed level for each of the potential uses for the digital dividend spectrum that we have identified. For some uses we conclude that there is insufficient evidence that any market failure will exceed the likely regulatory failure. In other cases we recognise the risk that there would be a market failure and propose intervention to alleviate it.

Summary

A7.54 Taking into account the elements of total value, how are the elements of value to society represented in market outcomes?

A7.55 Under a market-led approach the market process allows a transparent trade-off between the value of one use and another, by market participants who possess relevant information and have incentives to operate efficiently. Under an interventionist approach the trade-off is less transparent and relies on the information and judgement of the regulator. Generally the market is more likely than the regulator to make this trade-off efficiently, and is hence more likely to result in an outcome in which total value (and hence value to society) is at its highest.

A7.56 However, there are some situations in which total value may not be maximised by a market-led approach. These situations are the result of “market failures”. Intervention may also fail to maximise total value due to “regulatory failure”. The choice between a market-led and an interventionist approach should take account of the risk and significance of both market and regulatory failures.

Market failures and interventions to maximise value to society

A7.57 If there are situations in which some elements of total value (and hence value to society) are not fully reflected in a market outcome, how should this be addressed in order to arrive at an outcome in which the overall value to society is maximised?

[25] This is particularly relevant when a decision over the allocation of a resource involves a number of inter-related choices which would be informed by the information on opportunity cost revealed in a market-led approach (for example, the choice over how much spectrum to use to deploy a DTT multiplex is dependent upon decisions over the desired level of coverage, the number of viewers who may need to upgrade aerials, attitudes to risk in relation to further international negotiation to secure improved coverage levels, as well as the value generated to producers and consumers by offering additional channels on the DTT platform).

Underlying logic of approach to assessing cases for intervention

A7.58 This approach to assessing whether an interventionist approach may be justified in the face of a market failure is based upon the following two principles:

- firstly, in order for total value (and hence value to society) to be maximised it is essential that we fully consider both sides of any trade-off, taking into account the costs as well as the benefits of regulatory intervention; and
- secondly, the need to understand the underlying cause of the market failure and as result the optimal approach to remedy it.

A7.59 The logic behind the first principle is that intervention to remedy a market failure should only be considered when it can be shown that the benefits of so doing are in excess of the costs. In order to assess this it is essential to consider each of the following in order to identify the net benefit or cost of intervention:

- the impact of the market failure (absent intervention);
- opportunity cost of intervening (the total value of the services forgone and the cost of the intervention itself);[26] and
- impact of regulatory failures (which capture the inability of regulatory decisions to reach outcomes that maximise total value both in the present and the future).

A7.60 The logic behind the second principle is that often there will be a number of different policy options which are available to resolve a market failure. In order for total value to be at its highest, it is important to identify the option which is most effective at least cost. This assessment is important as not all policy options are equal – some will be more effective than others, will have differential levels of opportunity cost and run differential risks of regulatory failures occurring. Therefore different policy options will result in different levels of benefits and costs. The best option will depend upon the cause of the market failure as well as other circumstances pertaining in the market (such as the number of market players, the degree of uncertainty etc).

A7.61 By combining these two principles together we have identified the following as the four elements which should be included when assessing whether an interventionist approach could result and in a higher value to society and hence may by justified:

- an assessment of the risk of market failure;
- identification of potential remedies;
- an assessment of the opportunity cost of intervention; and
- an assessment of the risk of regulatory failure.

[26] By definition a market failure is only present when the cost of the market failure (the lost benefits which result) is greater than the opportunity cost of intervening (the benefits you forgo as a result of your intervention).

A7.62 Once these four elements have been considered it is generally possible to reach an evidence-based conclusion on whether the net benefits of intervention are sufficient to justify intervening.

A7.63 Each of the elements is now discussed to elaborate on the analysis which may need to be completed in relation to each.

A7.64 **Assessment of the risk of market failure:** The purpose of this is to assess the likely impact of the market failure. In order to do this it will involve an assessment of at least some of the following issues:

- the relevance of the market failure to the service under consideration, based on whether the conditions which need to hold for the market failure to occur are plausible;
- the likelihood of the market failure occurring, based on whether the conditions which need to hold for the market failure to occur are likely; and
- the significance of the market failure, which will include an assessment of the cause of the market failure and the resulting impact it will have on total value (ie its impact on the value to society) and will seek to quantify, where possible, the magnitude of this impact.

A7.65 **Identification of potential remedies:** this involves assessing the applicability of different intervention options given the cause of the market failure. The purpose of this is to identify those options which are likely to be most effective in resolving the market failure.

A7.66 There are likely to be a number of different intervention options which are available to resolve a market failure issue and some of these options are likely to be more effective than others in reaching a near optimal outcome.

A7.67 The range of intervention options which typically exist when resolving market failures in relation to spectrum allocations range from direct grants of spectrum, to intervention within an award (such as bidder credits or the provision of subsidies), to auction design changes (such as alterations to packaging and auction rules to equalise the opportunities for different bidders).

A7.68 **Assessment of the opportunity cost of intervention:** for remedies which are likely to be effective, this element assesses the opportunity cost (ie lost value to society) of the intervention. The opportunity cost of intervention will in most cases differ between the intervention options. Generally, interventions which are more restrictive in form are likely to have a higher opportunity cost than interventions which are "lighter touch", particularly when the level of uncertainty is high.

A7.69 In order for intervention to be justified the opportunity cost of intervening must be less then the cost of the market failure absent intervention[27]. However, as the benefit of resolving a market failure is often difficult to establish with any degree of accuracy the assessment of opportunity cost (which is in many cases easier to

[27] In theory for a market failure to be present the opportunity cost of intervention must be less than the cost of the market failure. However, this assessment of the net benefits does not take into account the impact of regulatory failure. Hence, once the effects of this are included, it may be the case that market failures are present in theory but in practice the benefits of intervention (taking into account all of the costs of intervention) are not greater than the costs of the market failure.

establish) provides a very important benchmark for assessment of market failure. This is because it allows an assessment of whether the uncertain benefits could plausibly exceed the possible opportunity cost.

A7.70 Further to this, the assessment of opportunity cost is a valuable indicator for the assessment of regulatory failures. If the opportunity cost of intervening is relatively low, then the impact of regulatory failure is likely to be less. Conversely, when the opportunity cost is particularly high a thorough consideration of regulatory failure is needed as the impact of getting the intervention wrong is likely to be much higher.

A7.71 **Assessment of risk of regulatory failure:** even when the opportunity cost of intervention is less than the cost of the market failure occurring, the impact of regulatory failures needs to be considered before intervention can be found to be justified.

A7.72 Regulatory failures can be categorised as follows:

- failing to achieve the desired effect – for example, when the policy is designed to provide users with an incentive to behave in a certain way but fails to achieve this because of a lack of information or because of a failure of the policy to take account of other related effects; and

- unintended consequences – these can be both static and dynamic and can affect both the market/users which are being regulated as well as other markets/users.

A7.73 The assessment of regulatory failures can involve a consideration of both how likely and how significant the regulatory failure might be. This analysis will generally take account of the key causes of regulatory failure. These include: uncertainty, informational asymmetries and complexity.

A7.74 As set out above, once each of the four elements set out above have been considered an assessment of whether the net benefit of intervention is likely to be positive can be completed. In other words, we can assess whether the trade-off involved in resolving the market failure is an efficient one for society, once all of the relevant costs and benefits have been taken into consideration.

Causes of market failure

A7.75 To assist in the application of the second principle set out above, we have identified three reasons that market failure might occur[28], ie why the ranking of outcomes based on producer value may not coincide with the ranking of the same outcomes based on total value:

- **Transaction costs -** When transaction costs result in some producers being able to express less of their producer value in a market-led approach than others – for example when there are transaction costs which make it difficult for producers to co-ordinate their activities to reflect their value in an auction bid.

- **External value -** When some uses generate disproportionate levels of broader social value or other external value compared to the producer value generated. This can be when there are consumer or producer externalities which are not

[28] We do not expect asymmetries in information to be a cause of market failure in relation to the award of the available UHF spectrum. However, the presence of asymmetric information is relevant to our analysis of regulatory failures.

internalised or where some uses generate broader social values when others do not.[29]

- **Structural differences -** When structural differences between markets mean that some producers are able to extract more producer value than others – for example when one producer faces less competition in a downstream market than another and as a result is able to earn profits which are higher because of its market power, not because it generates more total value.

A7.76 As discussed above, if a market failure occurs because of one of these causes set out above, this could result in a situation in which the value to society (ie total value) is not maximised. Therefore, these are situations in which further consideration should be given to whether an interventionist approach could result in a better outcome than a market-led approach.

Reflecting citizen interest in decisions

A7.77 The inclusion of broader social values within our framework of total value means that the presence of citizen interests would be captured by an assessment of market failures which result from the presence of external value. As set out earlier, it is not the presence of the external value itself which causes the market failure. It is when the level of broader social value (or citizen interest) generated by some of the services which could use the available UHF spectrum is disproportionately greater than that generated by other services.

A7.78 For example, if a service such as local TV, which could by the nature of its content help to foster a sense of belonging to a community, generates significantly more broader social value compared to other uses such as, for example, PMSE, HDTV or mobile multimedia this could result in a market failure, the cause of which is the presence of the broader social (ie external) values. That is, the total value of local TV might not adequately be reflected in a market-based award process (this issue is discussed in more detail in Annex 8 below).

A7.79 However, the potential impact of intervention upon broader social value, as well as other sources of value, is also important. So, when considering the costs of intervention and regulatory failure, we should take into account any broader social value which is lost from intervening. The analysis of the net benefit or cost of intervention will therefore consider the broader social value which is gained (in addressing the market failure), but also the broader social value which is lost through denial of spectrum to alternative uses (opportunity cost) and regulatory failure[30].

A7.80 This approach is consistent with the approach we took in the PSB review. That review set out two approaches to identifying whether intervention is required in relation to public service broadcasting. The first approach was a “market failures” rationale for PSB, the second approach was a “social values” rationale:

- the “market failures” approach is based upon the primacy of the consumer and advocates intervention only in the case of market failures; and

[29] Our analysis of external value captures market failures which arise due to missing markets.
[30] The net benefit or cost of intervention will consider the net effect on other sources of value too alongside broader social value.

- the “social values” approach is based upon wider societal goals and advocates intervention to achieve social goals (such as education and cultural identity) and in relation to distributional and industrial policy concerns.

A7.81 In the PSB review we concluded that these two approaches are very similar[31]. Both are concerned that the market will under-provide certain types of programming, in particular those programmes which generate positive externalities to the individual or society as a whole.

A7.82 Therefore, we consider the approach to assessing cases for intervention and our framework of total value are a natural extension of the work completed in the PSB review. They take this work forward to explain more precisely how the inclusion of broader social values, which are driven by citizen interests and hence the achievement of social goals, allows a market failures based approach to incorporate the underlying objectives of a “social values” based approach to intervention.

Summary

A7.83 If Ofcom finds evidence of situations in which some elements of total value are not fully reflected in a market outcome, how should this be addressed in order to reach an outcome which maximises the value generated to society?

A7.84 If Ofcom finds evidence of situations in which total value is not maximised in a market outcome, this should be addressed by undertaking an assessment of:

- what is the cause of the loss of total value (ie the market failure);
- how severe is the lost total value (ie the size of the market failure);
- the range of policy options for remedying this situation, including their respective costs, including opportunity cost and regulatory failure; and
- whether the policy options result in a higher level of total value overall.

Conclusions

A7.85 What are the key messages we can take from this work?

- welfare analysis allows us to capture total value, which allows the interests of citizens and consumers to be considered within a combined assessment of value. This allows policy decisions to take account of all interests within one approach to the assessment of costs and benefits;
- markets utilise information and respond to incentives which will move them towards the optimal outcome in most situations. However, a market-led approach can fail to maximise total value (and hence value to society) because of market failures. But this does not mean that intervention is required, still less that any intervention should be at the level of the spectrum input. There are costs of intervention, and regulators’ actions are unlikely to be fully effective or may have unintended consequences (ie regulatory failure);

[31] Discussion of this issue can be found at:
http://www.ofcom.org.uk/consult/condocs/psb/psb/sup_vol_1/concept/bringing/

- in order for total value to be maximised it is essential to consider both sides of any trade-off, taking into account both the benefits and costs of intervention. This means that intervention to remedy a “market failure” should only be considered when it can be shown that the benefits to society of so doing are in excess of the costs;

- hence it is important to understand the underlying cause of the market failure in order to identify the different policy options which may be available to resolve it as these policy options may be associated with different costs, either different opportunity costs or different risk and sizes of regulatory failure (or both). In order for total value to be at its highest it is important to identify the option which is most effective at least cost; and

- the existence of broader social value is a common one in relation to human activities, providing a fundamental rationale for the existence of public institutions. However, in most cases, intervention is made at the level of output (eg funding education or defence) not by controlling the use of inputs (eg labour and spectrum).

Annex 8

Detailed assessment of arguments for intervention

Introduction

A8.1 The purpose of this Annex is to provide a detailed assessment of the arguments which have been raised in relation to the presence of market failures affecting potential uses of the available UHF spectrum.

A8.2 These arguments are covered at a high-level in Section 6, where a summary of our conclusions in relation to each service can be found.

A8.3 The services which are covered in this annex are as follows:

- PMSE for community use;
- PMSE for professional use;
- low power applications;
- local television;
- mobile broadband;
- national DTT (excluding high definition services); and
- high definition on DTT.

A8.4 This annex does not discuss two other potential uses of the UHF spectrum: mobile communications and mobile multimedia, as we have not identified market failure concerns warranting detailed assessment in relation to these two services.

A8.5 The structure of this annex is as follows. For each service we provide analysis of the following:

a) the potential market failure arguments,

b) the relevant evidence,

c) the assessment of the validity of the market failure arguments,

d) the opportunity cost of intervention; and

e) the potential remedies to the market failure, including an assessment of the benefits and cost of intevention, which include the impact of regulatory failures.

A8.6 Based upon this discussion, a summary is provided of the outcome in relation to each of the four elements of the analytical framework (as set out in Annex 7 above).

PMSE community use

Summary

A8.7 Set out below is a summary of the result of our assessment against each of the four elements which need to be considered to allow an assessment of whether intervention is justified to resolve a risk of market failure (as set out in Annex 7 above).

A8.8 Further detail on these potential market failures and our assessment against each of the four elements is provided in the following paragraphs.

Figure 8.1 A summary of application of analytical framework to PMSE community use

Identification of market failure argument	Transaction costs and the potential for free-riding mean that any bid for spectrum (based on willingness to pay for spectrum) might understate the total value to society of this use
Assessment of risk of market failure	The nature of the use means that there could be significant transaction costs involved in putting together a bid for spectrum (especially given the potential for free-riding). These mean that a bid would be unlikely to adequately reflect the total value of this use, and it is possible that no bid would emerge at all This use has both private and broader social value, albeit unquantified. Willingness to pay for spectrum is unlikely to adequately reflect the broader social value generated. This could result in a market failure if this use generates relatively more broader social value than other potential uses of the UHF spectrum. Evidence over the levels of broader social value generated is limited and highly uncertain
Options for intervention and opportunity cost of spectrum	Option 1. Set aside spectrum for PMSE on a licence-exempt basis - this would address the market failure. Could have a opportunity cost if consumers and citizens do not really want this use and other possible uses are excluded, but likely to be low due to international constraints on the use of channel 69 for which the exemption is proposed Option 2. Auction spectrum on nationwide basis with no intervention -low cost but likely to be ineffective as successful bid by PMSE community use is unlikely. The free-rider problem would not be addressed and this would not allow licence-exempt use, which is likely to be more efficient than licenced use given the non-rivalrous nature of the use
Assessment of risk of regulatory failure	Option 1. Set aside spectrum for PMSE on a licence-exempt basis - low to moderate – given theuncertainty over future alternative uses of the spectrum Option 2. Auction spectrum on nationwide basis with no intervention - moderate - may be ineffective as it does not address free-rider problem and would not allow licence-exempt use, which is likely to be more efficient given the non-rivalrous nature of the use. In addition this option could result in congestion from unmanaged use in the future
Conclusion	Make some or all of channel 69 licence-exempt for community PMSE use

Description of service

A8.9 One of the current uses of the available UHF spectrum is for programme-making and special events. This use comprises some tens of thousands of users of spectrum for wireless microphones and similar equipment such as in-ear monitors. The Joint Frequency Management Group (JFMG) manages assignments, and licenses PMSE use, on Ofcom's behalf. Various parts of the radio spectrum are made available to JFMG for this use, including the current interleaved spectrum (spectrum used in parts of the UK for terrestrial television broadcasting) and

channel 69, which is adjacent to these channels and which has been brought under the remit of the Review.

A8.10 The available UHF spectrum is suitable for PMSE use because there is a pre-existing bank of installed equipment that is tuned within these frequency bounds. The spectrum requirement for PMSE use at UHF is typically low power and short-range and, in many cases, short-term with dynamically changing and sometimes unpredictable demand – for example, to cover rapidly-breaking news stories. Consequently, PMSE lends itself to localised and opportunistic use of vacant spectrum. For this reason, in the UHF band, PMSE has been a significant user of the interleaved spectrum as well as of channel 36, channel 38 and channel 69.

A8.11 PMSE use divides, broadly, into two categories: community use, and professional use, the former described here and the latter described in the following section. A very large number of small organisations and individuals use the available UHF spectrum for community and small-scale commercial purposes. This includes users such as small theatres, places of worship, schools, universities, pubs and local events. They have a mixture of short-term and long-term assignments, but the assignments tend to be fairly simple – predominantly low usage with an average of four radio microphones per assignment. There is already some licence-exempt use of channel 70 by users in this category.

A8.12 In fact it may be more accurate to distinguish between users of PMSE who require an assurance of high quality of service (who therefore need assignments that are planned and coordinated) and those who can accept shared (ie uncoordinated) use. In this document we use “professional” and “community” as descriptions of these two types of use, while recognising that these are no more than loose analogies.

A8.13 JFMG currently issues many licences on a shared basis in channel 69, meaning that some users do not receive individually planned frequency assignments and receive no protection from interference from neighbouring PMSE licensees. If they experience interference from other PMSE users, they are expected to tolerate this or to tune equipment up or down the band to avoid it. The equipment that is permitted for use is low power, which limits, but does not eliminate, the risk of interference between neighbouring assignments.

A8.14 In addition, evidence suggests that there are numerous unlicensed users in channel 69 and adjacent channels, using PMSE equipment such as radio microphones but without a licence to do so from JFMG.

Possible arguments for intervention

A8.15 There are two possible reasons that a market-based award of the available UHF spectrum might result in community PMSE acquiring less spectrum than would be socially optimal: 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 the willingness to pay for spectrum.

A8.16 First, in certain cases, the transaction costs incurred by potential users of spectrum can make it too expensive for them to secure the socially optimal amount of spectrum:

- in cases where there is a large number of users, it might not be possible for individual users to co-ordinate their demand in such a way as to allow the benefits available to be reflected in a bid. It might be possible for a band manager

or other agent to co-ordinate demand on their behalf; but where there are very large numbers of very small-scale users, this is a difficult and expensive task and could still mean that the band manager's willingess to pay for spectrum would not reflect the true value available to all potential users; and

- further, if it is possible to use the spectrum without undue interference to other users, then free-riding becomes a possibility. Such use is known as "non-rivalrous" use, that is where use by one person does not interfere with, or exclude, use by another person. When free-riding is a possibility, there is no incentive for any individual user to identify himself and contribute anything towards a collective bid. Each user has an incentive to claim his private value is low, on the assumption that the value stated by other users will be high enough to ensure access to spectrum; the resulting collective willingess to pay for spectrum will significantly understate the private value to users.

A8.17 Both co-ordination costs and free-riding can have the effect of depressing any bid such that it does not adequately reflect the total value to society available from the use concerned. In some cases, no bid may emerge at all. Hence, there is a risk that insufficient spectrum will be allocated to this use.

A8.18 Secondly, there might be broader social value generated by community PMSE use that is unlikely to be reflected in users' willingness to pay for spectrum. However, it is difficult to estimate the size of this value. If there is relatively more broader social value generated by community PMSE use than other potential uses of the UHF spectrum this could result in a market failure and hence insufficient spectrum being allocated to this use.

A8.19 If our evidence suggests that there are significant transaction costs, a major free-riding problem, or substantial broader social values associated with community PMSE use, and these are likely to result in an inefficient allocation of spectrum, there may be a case for intervention in some form to ensure sufficient access to the available UHF spectrum to meet the needs of this use.

Evidence gathered for the DDR

Technical analysis

A8.20 The first question is what spectrum could community PMSE use, and what else could use that spectrum? An estimated 95% of all new radio microphones sold are intended for use in channel 69, as it is available nationwide for PMSE use. Much of this equipment also tunes over channels 67, 68 and 70.

A8.21 If channels 67-70 were not available then the majority of community PMSE equipment would need to be replaced. For lower frequencies, equipment is still readily available, but at higher prices and not in the same volumes as for the higher frequencies.

A8.22 Use of channel 69 in the UK is constrained by its use by French military radio, which prevents its use in the UK for high-power applications such as broadcasting. It is possible that in future other services could use this channel within the international constraints, for example other short-range devices. However, a change of use of the channel could involve clearing the band of PMSE users, if the new use(s) could not co-exist with PMSE, which would be time-consuming, costly and maybe practically impossible given the scale of current use.

A8.23 Ofcom has carried out an analysis of the potential of PMSE to interfere with other low power applications, and *vice versa*, to assess whether there might be scope for PMSE to co-exist with other low power applications in channel 69, or other cleared channels. Our current assessment is that sharing a single channel in this way is likely to cause unacceptable levels of interference.

A8.24 In time, it is possible that community PMSE equipment could become more efficient in terms of spectrum use in future. Currently, PMSE usage is relatively inefficient in spectrum terms, and could be improved by switching to more efficient technologies or by better co-ordination of assignments. Digital microphones, for example, are more efficient users of the spectrum as they offer the benefit of wider tuning range, which can relieve congestion by offering users a wider range of available channels. Current typical analogue radio microphones have a tuning range of just three channels; the best models can range over 10 channels.

A8.25 However, most radio microphones in current use are analogue, with little migration to digital equipment at present due to the increased cost and size, limited battery life and latency issues posed by digital microphones. Significant investment is required to improve digital microphones to the quality provided by analogue equipment. Unfortunately, this investment is unlikely to occur in the short-term. This investment is only likely to occur if there is a commercial driver for it, and is unlikely to be led by community PMSE use. This issue is discussed further in the section on professional PMSE use.

Market research

A8.26 The market research commissioned by Ofcom in 2006 did not explore consumers' or citizens' attitudes towards community PMSE use. As this use is not consumed directly by consumers, and the extent of its use may not be readily observable, it would be inappropriate to apply the techniques used to assess the value of other candidate uses to PMSE.

Stakeholder engagement

A8.27 By their nature, it is difficult to engage community PMSE users in a formal and technical consultation of this kind. Users are widely dispersed, have no single representative body and may be largely unaware of the regulatory framework as it relates to their use of the spectrum. Indeed, the extent of unlicensed use suggests that many users may not be aware that there is a regulatory framework at all.

A8.28 For these reasons, the consultants working on this study did not formally consult community PMSE users but based on discussions with JFMG it was possible to infer some general features of their requirements. There is a large number of community PMSE users, running into the tens of thousands, whose use is largely local and includes commercial, semi-commercial and community activities. They have equipment and established patterns of use that may be costly for them to change. Without having conducted formal engagement with this user group, we expect that their priority is to be able to continue to do what they do now, without incurring significant additional costs.

Demand analysis

A8.29 It is difficult to be precise about demand for community PMSE, not least because of the high level of unlicensed use of channel 69, and to a lesser extent channel 67-68, by this service. As a guide to demand, in 2005, JFMG issued over 30,000

licences for radio microphones across the whole radio spectrum, including both professional and community use, and just under 2,700 licences for talkback. A breakdown between community and professional users is not available on a channel-by-channel basis; but a comparison of equipment sales with licences suggests that for every licensed use of microphones in channel 69, there are two unlicensed uses, suggesting that there could be a substantial number - running into the tens of thousands - of unlicensed, and strictly illegal, PMSE users currently occupying channel 69.

A8.30 Future demand is a function of the number of organisations making use of PMSE, and the extent of their use of equipment. A study commissioned by the DDR from Sagentia (formerly known as Scientific Generics) estimated future demand for PMSE by considering both these factors. It forecast year-on-year increases of 30% in the demand for PMSE amongst community organisations, and 12% in demand from small-scale commercial organisations. The take-up of PMSE equipment for both uses was forecast to increase by 25% between 2006 and 2009, and 15% between 2010 and 2012.

Economic modelling

A8.31 It is difficult to estimate the willingness to pay for spectrum for community PMSE use. As described above, the users are many and disparate, and some may not even have continuous existence between specific community events. It is therefore difficult to consult them on their private values. Those users who are not licensed at present are also very difficult to identify.

A8.32 The broader social value generated by community PMSE is similarly difficult to estimate. The use of wireless microphones in places of worship improves access to these services for some people, for example those with hearing difficulties, and also potentially improves the experience for all those in attendance. Similarly, using wireless microphones at community events such as school open days or fetes contributes to improved access and a better quality of experience. Events in pubs and social clubs can also contribute significantly to a sense of community belonging and social inclusion. Wired PA systems are a potential alternative but can be necessarily limited by health and safety requirements.

A8.33 Some religious and community activities have broader social value that is recognised in their tax status, although it is difficult to quantify. The tax-exempt status of these and similar organisations, and public and charitable investment in infrastructure to support community activities, are arguably an implicit recognition of this broader social value.

A8.34 Consultancy studies commissioned as part of the DDR identified that PMSE – including both commercial and community use – could deliver broader social value.[32] This value could be substantial as use is so widespread although it is unclear whether events at which PMSE equipment was used would not happen, or would be significantly negatively affected, if spectrum were not available.

Assessment of case for intervention

A8.35 The following paragraphs assess each of the possible arguments for intervention outlined above, based on the evidence collected in the DDR. This analysis seeks to

[32] DotEcon, Damian Tambini, 'External value of candidate uses for the digital dividend spectrum', 2006

establish whether there is reason to believe that the factors identified would, in fact, mean that a market-based approach to the award of the available UHF spectrum would be likely to result in a suboptimal outcome for society.

A8.36 This section does not attempt to assess the benefits and costs of any potential remedies; nor does it discuss whether these remedies would be an appropriate solution to any problems identified. These issues are covered in a separate section.

A8.37 The number of current community PMSE users run into the tens of thousands, including unlicensed users. Many of these users are very small-scale, hiring equipment maybe once or twice a year. It seems likely therefore that the transaction costs involved in co-ordinating a bid which reflects the total value of all of these users would be very high.

A8.38 Community PMSE uses are generally non-rivalrous, which is what enables licences to be issued on an uncoordinated basis. This is partly because PMSE use is relatively low power, but very importantly, in the case of community PMSE, because users are geographically distributed.[33] As a result, we would expect some free-riding to be a risk in an auction and after any market-led allocation to community PMSE. The substantial free-riding at present by unlicensed users suggests that this would be the case.

A8.39 From these characteristics of community PMSE use, it seems likely that an auction could lead to a sub-optimal allocation of spectrum to this use.

A8.40 In addition, although both the private and external elements of the value of community PMSE use are hard to quantify, the consultants' analysis indicates that it is likely that there is some value to society here, including broader social value. The cost of transitioning this use to another part of the spectrum, or of losing all or some of it, may well be higher than the opportunity cost of accommodating it in the available spectrum.

A8.41 This is because there are reasons why channel 69 is particularly valuable to these users, but of lesser value to other uses (owing to international constraints and the costs of clearing the incumbent PMSE use). Whilst the value to society of community PMSE use (including any broader social value generated) could potentially be realised using a different spectrum allocation, the costs of replacing equipment could be difficult for some of the smallest organisations to meet. Hence, the incremental value of channel 69 for these users would be high relative to the absolute value of their use.

Opportunity cost of spectrum

A8.42 The opportunity cost of accommodating community PMSE use will depend upon how much spectrum is required and where in the spectrum band the spectrum is located. It is likely that the amount of spectrum required will be small, given the low power nature, and geographical distribution, of community uses.

A8.43 The opportunity cost of community PMSE using one 8 MHz channel is the value to society of the alternatives that are excluded. Because of the constraints on use of channel 69, and the large number of existing users, including unlicensed users, the

[33] For comparison, professional PMSE use is often geographically concentrated, creating congestion and potential interference, and requires high-quality access to spectrum, so is therefore not considered to be non-rivalrous.

opportunity costs in relation to this channel are likely to be relatively low compared to that which would be incurred in relation to other available channels.

Potential remedies, benefits and costs

A8.44 There are three options for remedying the market failure which could occur in relation to this use. The first is to set aside channel 69 for community PMSE use on either a licensed or licence-exempt basis. The second option would be to ensure that the auction design minimises the transaction costs which this use would incur. And the third option would be to ensure that sufficient funds are available for this use to realise the value to society it generates in a market-led award process.

A8.45 The second and third options can both be dismissed at this point as they would be unlikely to fully resolve the risk of market failure. Under the second option, there is a limit to the extent that auction design could be used to minimise the transaction costs which this use would incur, and the potential for free-riding to substantially depress the bid would still remain. Additionally, while the option of ensuring sufficient funds are available could help to ameliorate the impact of free-riding and help to ensure that broader social value is adequately reflected in the willingness to pay for spectrum, the third option would still be hampered by the transactions costs which, as mentioned above, it would be difficult to fully remove via auction design. Further to this, both of these options would be likely to incur unnecessary administrative costs if this use could alternatively be accommodated on a licence-exempt basis. This point is discussed further below.

A8.46 The first option is to set aside channel 69 for community PMSE use either using arrangements similar to the present licensing regime or on a licence-exempt basis. The two variants of this option are discussed below.

A8.47 Making channel 69 available for community PMSE use, using similar arrangements to the present licensing regime, would continue to make channel 69 available for PMSE and would therefore avoid the loss of benefits, including broader social value, from PMSE activity in the channel. It would also avoid imposing on current users the costs associated with switching channels. However, where use is truly non-rivalrous, licensing use leads to inefficiency, as people who could use the spectrum, generating benefits for themselves at no cost to others, may be excluded from the spectrum.

A8.48 Making the licences free and available on demand minimises this risk, but entails unnecessary administrative work which has costs, and few discernible benefits. For example, because users do not generally interfere with one another's use, there is little chance of unlicensed use causing a nuisance, and thereby being detected; so not all users will choose to be licensed.

A8.49 The second variant of this option is to make all or part of channel 69 licence-exempt for PMSE users. This approach makes the spectrum as widely available as possible, at minimal cost. It would offer significant benefits to users, who would not need to acquire licences or pay any fees for the use of the spectrum. Since much of this channel is already made available on an uncoordinated basis, and there is no guarantee of protection from interference from other users, there would be little difference for users in these aspects of their spectrum use.

A8.50 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).

A8.51 If the marginal benefits – in terms of both producer and consumer value and broader social value – of community PMSE using the available UHF spectrum are sufficient to warrant an intervention in the market allocation of spectrum, the most efficient form of intervention appears to be the creation of a licence-exempt channel for this use.

A8.52 There are potential costs arising from this option. Such a move would pre-empt the auction process and so have risks that more valuable uses would be excluded from access to the licence-exempt spectrum. However, as discussed above, licence-exemption for this channel is likely to have a relatively low opportunity cost.

A8.53 There is the potential for greater opportunity costs in the future depending on how different technologies, and the markets for those technologies, develop. This is because the licence-exempt spectrum is not tradable in the after-market in the same way as licensed spectrum is. It is not possible for the market to re-allocate licence-exempt spectrum to more productive uses, without a further regulatory intervention to remove licence-exempt status and release the spectrum afresh.

A8.54 Finally, we recognise that not all users will necessarily prefer uncoordinated use of this spectrum in future, despite the benefits of reduced cost and administration it offers. Some users might prefer the greater guarantees and protection offered by coordinated assignments, in channel 69 or elsewhere, particularly small commercial users.

A8.55 As with all interventions, we need to consider the potential for regulatory failure in excluding this channel from any auction. Regulatory failures could include:

- failure to achieve desired effect. In this case, such failure would occur if there were no, or insufficient, demand for community PMSE use in channel 69 after DSO. Given that current demand is evident, and equipment will continue to be suitable for use in this channel after DSO, this risk seems low; and
- unintended consequences. Of those we can foresee, making spectrum freely available may reduce incentives on users to improve the efficiency of their technology. However, as use is confined within a specified channel that would be dedicated to community PMSE, the costs of any relative inefficiency would generally be contained within the sector, and the non-rivalrous nature of much use in channel 69 might mean that the cost of introducing more equipment that is more spectrum-efficient is less than the gain. Second, making spectrum free on demand might lead to congestion in the channel in some parts of the country. However it would be open to some or all community users to switch to equipment usable in other licence-exempt bands (where their use is consistent with the technical restrictions on the use of the band); or to seek to obtain spectrum

assignments on the open market, that would be exclusive and free of interference; or to make a case for additional licence-exempt spectrum for this use.

A8.56 The key question for Ofcom is therefore whether the total value to society generated by exempting use of channel 69 for PMSE use is greater than the cost of doing so? The preceding analysis suggests that the benefits of doing so are uncertain, but could be substantial; while the costs of doing so are likely to be relatively low. However we recognise that some use of channel 69 is presently on a coordinated basis, and therefore would welcome views on whether this could be accommodated in other bands, or whether some of channel 69 should be reserved for coordinated use rather than made fully licence-exempt.

A8.57 Ofcom has also considered whether, if PMSE use in channel 69 were exempted, other low power devices should be allowed to share the channel on a licence-exempt basis or whether channel 69 should be reserved exclusively for PMSE. This depends largely on whether PMSE can co-exist with other low power applications without harmful interference and whether there is sufficient spectrum available to accommodate more than one application. As described in the Technical Limitations section, the answer is that this is unlikely to be the case. In addition, the benefits are likely to be relatively low, since channel 70 is already available for use by short-range devices on a licence-exempt basis. We therefore conclude on the basis of that analysis that if use of channel 69 by PMSE were to be exempted, the channel should be reserved exclusively for PMSE.

Ofcom's proposal

A8.58 We propose that channel 69 should continue to be available and made licence-exempt, for PMSE community use. We would be interested in hearing from stakeholders on whether transitional measures for phased exemption in the band may be suitable.

PMSE professional use

Summary

A8.59 Set out below is a summary of the result of our assessment against each of the four elements which need to be considered to allow an assessment of whether intervention is justified to resolve a risk of market failure (as set out in Annex 7 above).

A8.60 Further detail on these potential market failures and our assessment against each of the four elements is provided in the following paragraphs.

Figure 8.2 Summary of application of analytical framework to PMSE professional use

Identification of market failure argument	Transaction costs Nature of user base makes co-ordination of demand expensive or impossible, depressing willingness to pay for spectrum	Ability to fund purchase Sector is unable to raise funds to allow a bid for spectrum	External values Use generates significant broader social value or spillover effects that are not reflected in willingness to pay for spectrum	Transition to market model Risk of disruption associated with transition. Time between now and auction not sufficient for all users to transition fully to market model. Possible shortfall in spectrum obtained for PMSE use at auction
Assessment of risk of market failure	Low / moderate – reasonable potential for band manager emerging to coordinate demand, though this may take time	Low – end users are accustomed to and capable of paying market prices for other inputs, no reason spectrum should be different	Low – external values of PMSE are assessed to be comparable to other uses	High – PMSE providers and their clients likely to need time to put appropriate mechanisms and funding in place
Options for intervention and opportunity cost of spectrum	Option 1. No intervention other than to package spectrum consistent with use by professional PMSE – low opportunity cost, low risk of market failure Option 2. Reserve spectrum for professional PMSE – potentially high opportunity cost. Disproportionate response where identified risk is time-limited			Option 1. No intervention other than to package spectrum consistent with use by professional PMSE – low opportunity cost, high (time limited) risk of market failure Option 2. Reserve spectrum for professional PMSE – potentially high opportunity cost. Disproportionate response where identified risk is time-limited Option 3. Make transitional arrangements to secure access to spectrum for PMSE for a limited period - potential opportunity costs (but time-limited)
Assessment of risk of regulatory failure	Option 1. No intervention other than to package spectrum consistent with use by professional PMSE – low/uncertain, given the low risk of market failure Option 2. Reserve spectrum for professional PMSE – high, risks of distorting business incentives and over-			Option 1. No intervention other than to package spectrum consistent with use by professional PMSE – uncertain, risk that arrangements are insufficient to address the market failure

	or under-supplying spectrum			Option 2. Reserve spectrum for professional PMSE – high, risks of distorting business incentives and over or under-supplying spectrum Option 3. Make transitional arrangements to secure access to spectrum for PMSE for a limited period – low, some risk of distorting incentives but only for limited period
Conclusion	No intervention justified. Discussion of transition is relevant	No intervention justified	No intervention justified	Package spectrum in way consistent with PMSE use. Consider how to implement transitional arrangements for highest benefit/lowest cost

Description of service

A8.61 One of the current uses of the available UHF spectrum, and other spectrum, is professional PMSE. Programme-makers, commercial theatres and event organisers use the 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.

A8.62 This use tends to be characterised by a mix of one-off, long-term, and permanent assignments with fixed geographic locations, such as large theatres, sports and concert venues and broadcast studios. For example, major theatres might use 50-100 radio microphones, plus some talkback and in-ear monitors. These users require the security of co-ordinated assignments to avoid excessive interference, and a guarantee of uninterupted use of the spectrum.

A8.63 Professional PMSE use is generally carried out under licences issued by JFMG on Ofcom's behalf and, like broadcasting use, has historically been allocated spectrum administratively. Under the previous model of spectrum management, the Radiocommunications Agency and other interested parts of Government (including the sector-specific regulators) identified spectrum for prescribed uses, and awarded it according to various criteria.

A8.64 The available UHF spectrum interleaved between the terrestrial broadcating use is very suitable for this use. This is in part because this use operates at low power and hence is unlikely to cause interference to broadcasting users but also because users have already invested in equipment that is tuned to work at the frequencies in this band. 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.

A8.65 Demand for spectrum for PMSE use is difficult to forecast because of the nature of use. Ofcom and its consultants have been working over the past year to try to establish some demand profiles for this use. We expect demand for spectrum to rise with time across all cateogries of PMSE use, but particularly for radio microphones. Spurs for growth include the increase in live news reporting and coverage of live events and increasing temporary spurs such as the Tour de France in the UK in 2007 and the 2012 London Olympics.

Possible arguments for intervention

A8.66 If the available UHF spectrum were to be awarded through a market-based process, would there be any risk that professional PMSE use would acquire less spectrum than would be socially optimal?

A8.67 In considering any case for intervention in relation to professional PMSE use, the first step is to consider how the sector might participate in an auction, without any interventions, to identify whether there are any reasons why this would not result in an optimal allocation to this use along with other uses.

A8.68 In the case of PMSE use, there is a split between long term static assignments and assignments that are often temporary. In addtion PMSE use is geographically disaggregated and split over a relatively significant number of different organisations. If the spectrum were auctioned, a "band manager" could make a bid, on the basis of a business model reflecting expected demand from customers. A band manager is an organisation that undertakes the management of a block of spectrum, which may involve a range of aspects of spectrum management such as planning use of the band and making assignments. Such an entity could be a commercial body, or a not-for-profit cooperative organisation established by the end users themselves, to bid for and coordinate spectrum use on end users' behalf. JFMG currently fulfils many of the functions of a band manager.

Transaction costs

A8.69 Some organisations and individuals have suggested that transaction costs in co-ordinating a bid for spectrum could make it likely that such a bidder could not secure the optimal amount of spectrum for this use, even if a band manager were in place.

A8.70 Transaction costs could arise from:

- a large number of small users, some of them difficult to identify; and/or
- free-riding risks (including the risk that some users will not identify themselves).

A8.71 The presence of significant transaction costs can result in a market failure as they deflate the willingness to pay for spectrum relative to the private (producer and consumer) value generated. This can result in the willingness to pay for spectrum not adequately reflecting the producer and consumer value generated which could result in an inefficient allocation of spectrum to the use concerned.

Ability to fund spectrum purchase

A8.72 Several stakeholders suggested in the course of carrying out this review that the professional PMSE sector would not have the financial strength to mount a bid sufficient to secure them enough spectrum.

A8.73 This would be a market failure if the inability to raise funds was due to a structural market failure which resulted in this use not being able to access funds which are commensurate with the value to society of their use.

External values

A8.74 There may be external values that are not reflected in willingness to pay for spectrum, possibly including broader social value associated with professional PMSE use, or other external benefits, such as spillover effects. If different uses generate proportionately different amounts of such values, the auction may allocate a sub-optimal amount of spectrum to one or more uses with high total values but lower private values.

Transitional issues

A8.75 In the specific case of professional PMSE use, there may be problems associated with the transition from the current model to a market-led model. These problems could include practical difficulties with withdrawing a major regulatory intervention in the provision of spectrum, transitional costs and issues related to the timing of the transition.

A8.76 These transitional issues do not necessarily constitute a market failure. If the current approach to allocating spectrum to PMSE does not result in the optimal use of the spectrum, then we need to consider making a transition to an approach that is more likely to do so, including adopting a market-based approach if appropriate, even if that imposes transitional costs.

A8.77 However, if the costs associated with making a transition to a market-based approach for professional PMSE exceed the likely benefits of doing so, over time, it may be more appropriate to retain the current approach for a period even if it is sub-optimal in its use of spectrum. Users would then have a longer period to adjust their behaviour in preparation for the new arrangements.

Evidence gathered for the DDR

Technical analysis

A8.78 Professional PMSE use currently takes place mainly in the interleaved spectrum, but there is also use in channels 36, 38 and 69. They currently uses all channels in the interleaved spectrum, ranging across both the lower part of the band and the higher part. The technology currently used can co-exist with both digital and analogue broadcasting use, so could continue to use the interleaved spectrum after DSO.

A8.79 Furthermore, the great majority of interleaved spectrum is unused at most locations for most of the time. Post-switchover, our analysis suggests that more than 95% of locations will require less than 20% of the available interleaved capacity. However, there is great presure on the spectrum at a limited number of locations mainly linked to special events, some events at some locations require all the available spectrum and at times require more spectrum than is available. This suggests that sharing with other applications could be problematic, particularly those with equipment that is not sophisticated enough to co-exist with PMSE without causing or suffering interference.

A8.80 The market analysis carried out by Analysys identified the other most likely source of demand for the interleaved spectrum as local DTT services, though other uses are possible (such as other low power services, and a quasi-national DTT multiplex). We have carried out a technical analysis to determine whether local DTT can co-exist with professional PMSE use. Its main relevant conclusion is that these

two services are considered able to co-exist. Further details of the technological requirements of professional PMSE use, and uses that it is compatible with, are in Annex 10.

A8.81 The effect of switchover on the availability of spectrum for PMSE in the UHF band is complex and depends on various factors such as how spectrum is allocated and assigned post-switchover, the local incidence of relay stations and how much of the spectrum is allocated to other uses. Overall, the total quantity of spectrum available for PMSE use is likely to decline at DSO, as the cleared channels with cease to be used by their existing primary use, analogue television, as well as well as by the secondary use, PMSE. However, the need to protect analogue relay transmitters from interference reduces the number of channels currently available for PMSE; after switchover, this constraint could be reduced, resulting in more spectrum being available. 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 (and other related studies by LS telcom and Quotient).

A8.82 The key conclusions we draw from this work are that:

- there is likely to be sufficient capacity in the interleaved spectrum that will exist in future to meet current demand for professional PMSE use;
- users will, however, need to retune equipment to be able to make use of the frequencies available in future; and
- 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 and the variety of alternative uses for interleaved capacity (such as local TV).

A8.83 The BBC has also carried out research into the implications of switchover for PMSE, which concluded that should the interleaved spectrum be available on the same basis as at present, the overall availability of channels for radio microphones should be significantly higher; for audio links, better on the whole, but with losses in a few locations; but somewhat worse for digital wireless camera links. However, there is little evidence of any significant demand for wireless cameras at UHF frequencies and few instances of licensed use in 2004-05.

A8.84 Our and the BBC's analysis suggests that switchover should not in itself cause a reduction in spectrum available for PMSE except at a few specific sites. The broader question is whether other uses, with high value to society, should be given the opportunity to access interleaved spectrum, which they do not have at present. The evidence for this is discussed in the Opportunity Cost section below.

A8.85 As noted in the section on community PMSE, the other question is whether PMSE could use spectrum more efficiently than at present. The case varies for different kinds of equipment. With respect to radio microphones, our analysis suggests that digital use may not *per se* be more spectrally efficient, but digital radio microphones do offer users the ability to tune to a wider range of channels. This might help relieve congestion in some of the more heavily used interleaved assignments. With respect to talkback equipment, efficiency could be improved, including by switching to digital equipment, although the costs of doing so could be significant. In-ear monitors operate at low power, and at present there is relatively limited use of

spectrum by programme links, so in both these cases the available efficiency gains are modest.

A8.86 Technological improvements have occurred which would allow PMSE users to make more efficient use of spectrum. New analogue microphones are more efficient and similar efficiencies could be achieved with the move to digital technology, but there are latency issues with this equipment which would need to be overcome. PMSE use is not at present showing signs of migrating to digital technology.

A8.87 This may partly be because the costs of using spectrum for PMSE do not, at present, reflect the true cost of that spectrum. As a result there is limited incentive for users to invest in more efficient equipment. Application of market mechanisms to the provision of spectrum would help establish appropriate incentives for PMSE providers, and could encourage investment in more efficient equipment to the extent that it is cost-effective to do so.

Market research

A8.88 The market research commissioned by Ofcom in 2006 did not explore consumers' or citizens' values for professional PMSE use. Since most consumers have no first-hand experience of PMSE use, and only extract value from PMSE indirectly, market research would not be an appropriate tool to identify the potential value generated by this use.

Stakeholder engagement

A8.89 Ofcom's consultants held discussions with broadcasters who are PMSE licensees, as well as with the British Entertainment Industry Radio Group (BEIRG). Ofcom also maintains regular contact with JFMG, and has received direct communications on behalf of BEIRG and its members as well as a number of other large PMSE stakeholder groups including the Production Services Association, the Society of London Theatres and the Professional Lighting and Sound Association (PLASA).

A8.90 Interest in using the available interleaved UHF spectrum for PMSE came from current users of the spectrum. Users were concerned that they will lose their current access to the spectrum, and will not have sufficient financial power to succeed in an open auction.

A8.91 Although many stakeholders expressed a preference for the continuation of the status quo, some have also said that, if this were not the option pursued, there should be transitional measures put in place to address PMSE suppliers' business uncertainty, for a limited period.

Demand analysis

A8.92 The principal parts of the UHF band in demand by professional PMSE users are the interleaved spectrum, channel 69 and also channels 36-38. Around half of professional users' equipment is believed to be for use in channel 69; our proposals for future use of that channel are set out in the Community PMSE section.

A8.93 As reported to Ofcom by Sagentia (formerly Scientific Generics) following a study into PMSE use in 2006, the demand for wireless communications for PMSE continues to grow. This demand is for services such as radio microphones, talkback and in-ear monitors. Growth is primarily in special events, and is driven largely by

approximately 25% per annum growth in the number of microphones demanded at each event.

A8.94 Due to improvements in spectral efficiency the overall spectrum demand is predicted to grow at 5–15% p.a. over the next 10 years. However, the growth of demand at geographic hotspots, such as London's West End, will be lower, at 2–5% p.a.

A8.95 In addition, there is substantial additional demand generated by exceptional events such as the Commonwealth Games and the Tour de France. Such events are infrequent, and setting aside spectrum for them would result in that spectrum lying fallow most of the time. Nonetheless these are an important use of PMSE services and it will be important to ensure that the total value generated by these uses is taken into account when assessing the total value generated by PMSE use of the spectrum.

A8.96 The 2012 Olympics and Paralympics are a special case. The Government has given a guarantee to the International Olympic Committee that sufficient and suitable frequencies will be made available for the Games and that no fees will be charged for this to the 'Olympic family,' which includes media and broadcasters covering the Games. Digital switchover in London is also scheduled for 2012. Irrespective of whether DSO in London takes place before of after the Olympics, it will be important to ensure that sufficient spectrum is available. As it takes forward work on the digital dividend, Ofcom will ensure that the interests of the 2012 Olympics and Paralympics are taken carefully into account.

A8.97 Analysis of demand also indicates how many different professional PMSE users exist, which will shed light on the likely transaction costs if they were required to co-ordinate bids for spectrum. Research by Quotient suggests that most usage is accounted for by a relatively small number of users. The top 11 users account for about a third of PMSE usage and the top 20% for 80% of usage.

Economic modelling

A8.98 The preceding analysis suggests that there is significant continuing demand for PMSE use, in the available UHF spectrum and in other bands.

A8.99 The private value of professional PMSE use has proved difficult to identify. Programme makers and other users have no incentive to express this while access is available at or below the administrative costs of keeping it free from interference.

A8.100 Our modelling work has identified that the producer and consumer value of PMSE use of the UHF spectrum could range from £100m to £500m. However, the upper end of this range represents a relatively conservative estimate of the possible willingness to pay of PMSE professional users. In addition, our consultants have also identified the potential for private value generated by PMSE use, particularly that in theatres and at other events, to accrue to ancillary industries and therefore not to have been captured in their quantitative work. So this estimate of private value may somewhat understate the true private value realised from PMSE use in this spectrum. The consultants' report has been published alongside this document and can be found at http://www.ofcom.org.uk/consult/condocs/ddr/report_analysys/

A8.101 A report commissioned from Europe Economics, which attempts to identify the value generated in the UK economy from the use of the electromagnetic spectrum, estimated that PMSE use contributes to around £400m of producer surplus in the

UK economy. This is derived from PMSE use not only in the UHF spectrum but uses located elsewhere in the spectrum.

A8.102 Therefore, the private value estimates from the modelling suggest that the value generated by PMSE users is significant enough to make them a potential high value use to society of some of the available UHF spectrum. The historical lack of market mechanisms in pricing the spectrum and industry structure makes estimates of the private value (of producers and consumers) of spectrum for PMSE use highly uncertain. However, some cross checks can be used to confirm that the value is significant, as detailed below.

A8.103 A large portion of the private value of PMSE use of spectrum comes from a few industries that use it extensively. The UHF band is particularly significant for the radio microphones used in news gathering and TV presenting. Wired microphones are considered to reduce the quality of TV output, as wires intrude in the picture.

A8.104 In the absence of alternatives, it is likely that such final users would be willing to spend at least a small but significant proportion of their budgets to avoid such quality loss. This measure alone can justify a large part of the estimated private value of the spectrum, as the news budgets of mainstream TV services are significant. Thus our conclusion is that, although the total value is difficult to quantify, there is evidence that relatively high private value exists.

A8.105 Assessment of the external value which may be generated by PMSE use identified that professional PMSE supports or enhances the generation of broader social value across a wide range of categories. For example, its contribution to broadcast news or educational programming helps to educate citizens and create an informed democracy; its contribution to theatrical and sporting events, and programme-making in general, support improvements in cultural understanding.

A8.106 The analysis of external value carried out by Dotecon and Dr Damian Tambini for the DDR concluded that there was the potential for professional PMSE use to create broader social value in a range of areas. However the size of these values is difficult to quantify and no more than the broader social value of a wide variety of other uses.

Assessment of case for intervention

A8.107 The following paragraphs assess each of the possible arguments for intervention outlined above, based on the evidence collected in the DDR. This analysis seeks to establish whether there is reason to believe that the factors identified would, in fact, mean that a market-based approach to the award of the available UHF spectrum would be likely to result in a suboptimal outcome for society.

A8.108 This section does not attempt to assess the benefits and costs of any potential remedies; nor does it discuss whether these remedies would be an appropriate solution to any problems identified. These issues are covered in a separate section.

Transaction costs

A8.109 The structure and nature of the current professional PMSE market does not suggest that transaction costs would create problems of insufficient willingness to pay for spectrum:

- number of users: in the case of PMSE professional use, the top 20% of users account for 80% of usage, suggesting that a potential band manager could identify its likely customer base with sufficient certainty to mount a reasonable bid; however we recognise that there is in aggregate a large community of users, and that this is very diverse in character; however all of these users are united by their need for co-ordinated access (see below); and

- free riding: professional PMSE use depends on planned and co-ordinated rights to each spectrum allocation, which makes the risk of free-riding small. Professional PMSE signals need to be of broadcast or commercial performance quality. If one user is to secure sufficiently high quality spectrum for his requirements, it is vital that other users are excluded from that spectrum in the neighbouring vicinity. Interference at almost any level degrades signals to below the standard required in broadcasting or theatres, so unauthorised use would be quickly detected; and similarly, unauthorised use is likely to be subject to interference itself, from authorised uses. It therefore seems unlikely that many, if any, users would be prepared to try free-riding on other users' preparedness to pay their full value of their spectrum.

A8.110 On balance, it seems reasonable to suppose that one ofrmore band managers could be established to bid for spectrum on behalf of this group of users, 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.

A8.111 As a result, Ofcom does not consider that these two sources of transacation costs are sufficiently strong in the professional PMSE sector to mean that the sector could not be represented in a fair and credible way in an auction. However, we address below the possibility that the design of the award process might itself encourage users to work together on a bid that represents directly their interests.

Ability to fund spectrum purchase

A8.112 A further argument made by some stakeholders is that the sector would not have the financial strength to mount a successful bid. This would be the case if, for example:

- the sector did not produce sufficient private value for its clients to fund the cost of the spectrum required – but in that case, (in the absence of external value considerations) this would not be the best use of spectrum and the use generating the highest bid should secure the spectrum. The evidence suggests that there is a good deal of private value generated for users from professional PMSE use, much of it based on access to good-quality spectrum;

- the sector was structurally unable to capture the private value of spectrum in its services, because of its business model, or those of its clients. It is the case that the current PMSE business model does not capture the opportunity cost of each spectrum assignment, but this is the result of historic regulatory intervention (reservation of spectrum and provision at administrative cost) rather than anything intrinsic to the activities concerned. The professional PMSE sector's clients are mainly commercial organisations, with a large collective turnover, capable of paying market prices for the goods and services they use; or

- the potential band manager was unable to raise capital to fund a bid, owing to the unfamiliar nature of the business. However, although the business model would be new, the band manager would have an established customer base, and little uncertainty over the likely nature of their future demand. Given a competitive capital market, there is no reason to expect that an otherwise viable band management bid would be unable to secure sufficient funding.

A8.113 The ability to charge opportunity cost for spectrum arises because the client base is a set of commercial businesses, all with access to capital markets and capable of paying opportunity costs for their other inputs such as land, labour and technical equipment. We therefore believe that in considering the case for intervention, we should assume that the PMSE sector, or a band manager or managers acting on its behalf, should be able to formulate a business case and fund the purchase of sufficient spectrum in a market-based environment.

External value

A8.114 The third potential source of market failure is external value, that is, the possibility that professional PMSE use generates a sufficiently large element of broader social value that its willingness to pay for spectrum seriously understates the total value available, compared with other uses.

A8.115 The external value generated by PMSE use is difficult to quantify, but would consist of the contribution that PMSE use makes to the external value generated by the activity it supports. In the case of professional PMSE use, this is likely to be concentrated in the generation of content that furthers the aims of PSB, but also to include social benefits from other broadcasting, and from public events, whether or not these are paid for by consumers. A full list of the possible broader social value from PMSE use (in general, that is community and professional use) is in our consultants' report.[34] This analysis also assessed the possibility that external value could be generated from spillover benefits from PMSE use into related markets. On this point, the consultants' concluded that many of the spillover benefits generated by PMSE users would be reflected in the willingess to pay for spectrum for PMSE use.

A8.116 However, our consultants did not consider that the external value directly attributable to PMSE use would be very substantial in proportion to its private value. There is therefore limited reason to expect an auction to result in a sub-optimal allocation to professional PMSE because of external values.

Transition issues

A8.117 In the case of professional PMSE use, we have identified sector-specific transition issues, which merit thorough consideration and which may justify transitional measures.

A8.118 PMSE for professional use is currently licensed by JFMG on a non-commercial, cost-recovery basis whereby users pay the administrative costs to JFMG of issuing licences and ensuring freedom from interference between assignments, but not the opportunity cost of excluding other users. As a result, it is possible that assignments

[34] See our consultants report which is published alongside this document at http://www.ofcom.org.uk/consult/condocs/ddr/report_analysys

made within this spectrum, because they are not made on the basis of competitive bids by users, are not optimal, that is they are not securing the optimal value to society available from PMSE use in these channels.

A8.119 The intervention that is in force strongly discourages the emergence of a commercial band manager for PMSE in advance of a new spectrum award, primarily for two reasons:

- all of the spectrum that PMSE equipment is currently tuned to is licensed by JFMG, so in advance of a new spectrum award there would not be spectrum of value for a commerical band manager; and

- the price for access to spectrum for PMSE presently does not reflect opportunity cost.

A8.120 The occasion of a new award of spectrum that is suitable for professional PMSE use creates the chance for one or more companies to emerge as potential band managers, and to bid for the spectrum. In order for a potential band manager to put together a business case, it will require:

- information about likely demand for spectrum – how much it should try to buy; and

- information about how much it can pay for this spectrum, that is, information about the likely private value that its customers will derive from PMSE use.

A8.121 The potential band manager should be able to gather fairly reliable information about the likely future demand for this spectrum for professional PMSE use. The number of assignments currently made by JFMG, combined with research published by Ofcom and any additional research carried out, should produce reasonable estimates as to how much spectrum this sector requires, and in what locations and packages.

A8.122 Information about the private value users will obtain from PMSE use is, as mentioned above, currently not easy to estimate. The potential band manager will need to conduct research among current and likely users to estimate this. However, there are strong reasons why this information might not all be available within the limited time before any auction.

A8.123 Some PMSE users are vertically integrated with their end clients. For example, PMSE users who form part of the BBC or ITV in-house production arms should be able to work out how much they are prepared to pay for spectrum with reasonable confidence. Note that this is not to say this will be a quick or simple process, just that within an integrated structure, information is available about how the end client – the production budget-holders, and commissioners behind them – would be able to ascribe a value to PMSE input to a programme.

A8.124 Similarly, some theatrical PMSE users are integrated within larger entertainment businesses, though much smaller than the broadcasters. They may be able to take a view on their value from PMSE use of spectrum, though we recognise this would be difficult.

A8.125 However, many other PMSE users are independent from their clients, and run businesses based on a large series of temporary contracts. Not only are these PMSE businesses often small, their clients are often small businesses too. It is

likely to take these clients, and users, some time to transition from the current model to a market model in which their private value for spectrum drives prices. It is uncertain, for example, whether existing contracts between PMSE businesses and their clients would allow PMSE providers to pass through increases in spectrum charges in the way that would be required for the market to operate effectively.

A8.126 The contractual relationship between these users and their clients will need to change to reflect an essentially new item, the opportunity cost of the spectrum. Such users will need time to get a feel for the new market conditions – for whether the new market structure has affected demand, for example, and for how prices might vary between locations or over time as demand rises and falls. Until these users have this information, there is a risk that they will simply be unable to tell any potential band manager an expected willingness to pay for spectrum, and as a result there might not be as much spectrum available for PMSE use after the auction, as there would be if the true private value and willingness to pay for spectrum were known.

A8.127 Over time, we consider that a functioning market will emerge for professional PMSE use. However, we also recognise that getting from the current arrangements to a mature commercial market in which values, and prices, are relatively easy for both users and their clients to predict, is likely to take more time than is available between now and the expected issue of the first spectrum licences for the available UHF spectrum.

A8.128 In order to ensure that consumers and citizens do not face the costs of potential disruption to PMSE provision that might otherwise result, we are proposing that access to some of the interleaved spectrum should be safeguarded for professional PMSE use for a limited time, to ensure that the new market has time to develop.

A8.129 Ofcom therefore wishes to consult on potential transitional measures, discussed under “potential remedies, benefits and costs”.

Summary

A8.130 For the reasons above, we do not consider that there is any reason to assume that a market-led allocation will result in a sub-optimal allocation of the available UHF spectrum for professional PMSE use, provided the spectrum is packaged in a way that does not rule out this use. The extent of private value generated by this use of spectrum, together with users’ requirements for exclusive, managed spectrum assignments, mean that a commercial band manager model would be feasible.

A8.131 Accordingly, we do not see a case for adjusting or intervening in the award mechanism in relation to this use at this stage: an auction-based award, with packaging that enables PMSE use, should enable this use to participate on a fair basis with other competing uses for the spectrum.

A8.132 However, although we think that a market model for professional PMSE use is feasible, we recognise that there is signifcant risk of disruption to this use over the years up to and during DSO. It will take time for sufficient information to be available to all of the market participants, and for the necessary changes in the various contractual relationships in this market to take place. In order to enable an orderly transition, we think transitional measures to safeguard access to spectrum for a limited time may be justified.

Opportunity cost of spectrum

A8.133 Professional PMSE use is currently accommodated in the interleaved spectrum as well as in channel 69, and owing to its characteristics it could be accommodated in the post-DSO interleaved spectrum. However, there are other possible uses of the spectrum including local DTT, other low power applications, and potentially a sub-national DTT multiplex. However, the range of potential uses of the interleaved spectrum is much less than for the cleared spectrum.

A8.134 The opportunity cost of PMSE using the interleaved spectrum is therefore likely to be much lower than for the cleared spectrum.

Potential remedies, benefits and costs

A8.135 This section discusses options for the award of the interleaved spectrum, as it affects PMSE. Options for channel 69 are set out in the community PMSE section, above.

A8.136 The first option is to package the interleaved spectrum in a way that permits PMSE use, but to impose no constraints on use of the spectrum. Rights to the spectrum would then be awarded by auction. Market analysis suggests that creating packages in the interleaved spectrum that would suit professional PMSE use would not rule out higher value uses to society, if they exist, and would enable potential band managers to make bids for the spectrum they want. This would create maximum flexibility in spectrum use, and since this packaging option is not expected to rule out any higher-value uses to society, opportunity costs should be low or nil. However this would be a substantial departure from the historic method of managing spectrum for PMSE, and is likely to rely on the development of a band manager to bid for spectrum on users' behalf.

A8.137 The second option is to reserve some or all of the interleaved spectrum for professional PMSE use. This would provide certainty for users, but imposes an opportunity cost, particularly given that demand for spectrum for PMSE varies to such a great extent at different times and in different locations. It would also do little to create stronger incentives for efficient spectrum use. There would be a risk of regulatory failure as a result of reserving either too much or too little spectrum.

A8.138 The third option is to auction the interleaved spectrum in packages compatible with use for professional PMSE, but with transitional measures, to enable PMSE users and their clients to adapt to a new, market-led model for obtaining access to spectrum.

A8.139 This is our preferred option. We propose that transitional arrangements should be made to ensure that a specified minimum amount of the interleaved spectrum continues to be made available for PMSE use for a period, at least until the end of 2012, following the end of DSO and of the peak in demand arising as a result of the London Olympics. We would like to work closely with the PMSE user community in designing these arragements.

A8.140 Our preferred approach would be to auction a number of packages of interleaved spectrum offering a nationwide footprint that would be suitable for use by professional PMSE users. (There would 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.

A8.141 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.

A8.142 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.

A8.143 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.

A8.144 A transitional approach would enable PMSE suppliers to maintain continuity of provision of the service – the front-office activity – while the supporting commercial arrangements, or back-office, are restructured in order to enable a more flexible, responsive market in spectrum assignments for the long term. This would have benefits to consumers, who are the final end-users of professional PMSE.

A8.145 This intervention would be temporary. As the market for spectrum develops, it would be expected that future changes in PMSE use would be driven by users, either PMSE suppliers or their own customers, rather than regulatory actions.

A8.146 As with all interventions, we need to consider the potential for regulatory failure in excluding this channel from any auction. Regulatory failures could take one of the following forms:

- failure to achieve the desired effect. In this case, such failure would occur if the arrangements were insufficient (eg, there was not enough spectrum earmarked for PMSE; access was not fair or competitive) or otherwise poorly designed. Alternatively, this type of failure could occur if alternative uses of the interleaved spectrum are so much higher in value to society that we should enable them to use the spectrum from the earliest date after the auction. The market analysis provided severally by Analysys, Quotient, LS telcom and Europe Economics suggest that this risk is low. We will consider detailed proposals, in light of consultation responses, in the coming months; and

- unintended consequences. Of those we can foresee, earmarking spectrum for a limited time may, conversely, depress incentives to find more efficient means of delivering PMSE services, whether with new technology, new spectrum, or in some cases non-spectrum delivery. However, this risk has to be weighed against the risk of a sudden shortfall in available spectrum for PMSE use, particularly in the context of the high level of demand that will result from the 2012 Olympics.

The effect will be time-limited, with no regulatory interference with incentives in relation to this spectrum at the end of the transition period.

Ofcom's proposal

A8.147 We propose to ensure that the packaging of interleaved spectrum at auction includes packages that are suitable for professional PMSE use.

A8.148 Additionally, we propose to consider making focused, proportionate transitional arrangements to make sure spectrum is available for PMSE for a temporary period, at least until the end of 2012 Olympics, along the provisional lines set out above.

A8.149 As it takes forward work on the digital dividend, Ofcom will ensure that the interests of the 2012 Olympics and Paralympics are takne carefully into account.

Low power use

Summary

A8.150 Set out below is a summary of the result of our assessment against each of the four elements which need to be considered to allow an assessment of whether intervention is justified to resolve a risk of market failure (as set out in Annex 7 above).

A8.151 Further detail on these potential market failures and our assessment against each of the four elements is provided in the following paragraphs.

Figure 8.3 Summary of application of analytical framework to low power use

Identification of market failure argument	Transaction costs and potential for free-riding mean any bid for spectrum (reflecting the willingness to pay for spectrum) would be likely to understate the total value to society of this use
Assessment of risk of market failure	The risk of market failure is currently judged to be uncertain The structure of this use (especially the potential for free-riding) mean understatement of demand is likely. However, demand for this spectrum for low power use is uncertain, so it is not clear that the total value to society of this use would be sufficiently high to form part of an optimal allocation in any case
Options for intervention and opportunity cost of spectrum	Option 1. Set aside spectrum for licence-exempt use – this has a potentially high opportunity cost if consumers do not really want this use and other possible uses are excluded Option 2. Package spectrum consistent with use by low power providers – low opportunity cost but this would not address the free-rider problem, if one exists, nor the fact that licence-exempt use is likely to be more efficient Option 3. Auction spectrum on nationwide basis with no intervention – low opportunity cost but this would not address free-rider problem, if one exists, nor the fact that licence-exempt use likely to be more efficient
Assessment of risk of regulatory failure	Option 1. Set aside spectrum for licence-exempt use: moderate – if the opportunity cost of setting aside spectrum turns out to be relatively high the risk of regulatory failure could also be relatively high Option 2. Package spectrum consistent with low power use - moderate, may not have the desired effect Option 3. Auction spectrum on nationwide basis with no intervention - moderate, may not have the desired effect
Conclusion	Wait until market information is clearer. If indications are that demand is sufficient to make this a high total value use to society, consider making additional spectrum licence-exempt

Description of service

A8.152 The available UHF 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 that used by shops and logistics organisations to track items, and wireless “last-mile” broadband access.

A8.153 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.

A8.154 The available UHF spectrum has some characteristics that are suitable for some low power uses, including the ability of signals at these frequencies to pass through walls. However, this characteristic may create interference risks with adjoining households, and raise security or viewer protection issues. The extent of interference between low power users will depend upon the power levels used (if it is possible to reduce the power levels used when transmitting in the UHF frequencies the propagation characteristics will become similar to those of higher frequency bands).

A8.155 However, the UHF spectrum also has some characteristics which makes it unsuitable for some low power uses. In particular, if the amount of spectrum available is limited, there will be restrictions on the data rates which can be supported using the UHF band compared to higher frequency alternatives.

A8.156 It is important to note that other parts of the spectrum can be used for such technology (with some bands already in use, eg 2.4GHz, 5GHz). Home hubs, and other low power uses, are currently accommodated in different parts of the spectrum, on a licence-exempt basis.

A8.157 Demand for additional spectrum for low power use, and for this spectrum in particular, is not currently easy to forecast. Similarly, it is difficult at this stage to estimate how much of the available UHF spectrum might be required, and thereby to identify the opportunity cost of excluding other uses.

A8.158 Ofcom is currently undertaking a wide review of its strategy for licence-exempt use. This is expected to lead to proposals in 2007.

Possible arguments for intervention

A8.159 If the available UHF spectrum were to be awarded through a market-based process, would there be any risk that low power users would gain access to less spectrum than would be socially optimal? Low power users would be free to participate in any auction of the spectrum, or to buy assignments from a band manager who has bid successfully for spectrum after the auction.

A8.160 However, in certain cases, transaction costs can depress the price below what is needed to secure the socially optimal amount of spectrum:

- in cases where there is a large number of users, individual users might not be able to co-ordinate their demand in such a way to allow the benefits available to be reflected in a bid. It might be possible for a band manager or other agent to co-ordinate demand on their behalf; but where there are very large numbers of very small-scale users, this is a difficult and expensive task and could still mean that the band manager's willingness to pay for spectrum would not reflect the total value available to all potential users. This is likely to be the case for some low power use where the user base could extend to all households, and possibly to all individuals; and

- further, if it is possible to use the spectrum without undue interference to other users, then free-riding becomes a possibility. When free-riding is a possibility,

there is no incentive for any individual user to identify himself and contribute anything towards a collective bid. Each user has an incentive to claim his private value is low, on the assumption that the private value stated by other users will be high enough to ensure access to spectrum; the resulting collective willingness to pay for spectrum will significantly understate the private value to users.

A8.161 Both co-ordination costs and free-riding can have the effect of depressing any bid for spectrum to allow low power use below the total value to society available from this use.

A8.162 Additionally, depending upon the nature of the low power use there might be broader social values generated by this use that are unlikely to be adequately reflected in users' willingness to pay for spectrum, and which could result in a market failure if lower-power uses generated relatively more of this value than other potential uses of the spectrum.

Evidence gathered for the DDR

Technical analysis

A8.163 It is important to note that if an intervention in the allocation process is justified, the precise nature of that intervention would depend on the likely technology, in particular whether it is rivalrous or non-rivalrous. Non-rivalrous use is where use by one user does not preclude, nor unacceptably interfere with, another person using the same spectrum band. This can be the case where the uses are very low power, or can be achieved at higher power levels by technological adaptations. For example, some uses operate a "listen then avoid" protocol whereby they first detect any signals in the band they are using and then re-tune to avoid those before transmitting.

A8.164 However, the available UHF frequencies have propagation characteristics that could be unwelcome for non-rivalrous low power uses. For a given power level, this means that signals at these frequencies will travel further and, in particular, will penetrate in-buildings better, which may cause interference between users. However, the extent of this problem will depend upon the power levels used (if it is possible to reduce the power levels used when transmitting in the UHF frequencies the propagation characteristics will become similar to those of higher frequency bands).

A8.165 Additionally, compared with other available licence-exempt bands at 2.4 GHz and 5GHZ, the relatively narrow bandwidth available at UHF mean that data speeds would be limited unless a large allocation is given to this use, with a correspondingly high opportunity cost.

A8.166 Ofcom's technical assessment of low power use of UHF spectrum has identified that this may or may not be cause interference which damages the value to society of adjacent channels which might be used by other services. Further work is required to establish the extent of this issue.

Market research

A8.167 Research commissioned by Ofcom identified that the consumer willingness to pay which could be generated by low power uses such as home hubs was relatively high compared to other potential uses of this spectrum. Our analysis showed that

22% of households would be willing to pay £5 a month for this service and that 5% of households would be willing to pay £15 a month.

A8.168 Our research into whether there is value to society from wireless home networks identified that the value to society of this use was perceived to be very low relative to some of the other potential uses of this spectrum.

Stakeholder engagement

A8.169 During 2006, Ofcom's consultants embarked on a programme of stakeholder engagement intended to allow potential users to inform the project via in-depth discussion as well as written representation. A number of stakeholders said they would like some of the spectrum to be identified for low power, licence-exempt use.

A8.170 Preference was expressed for channels cleared nationally for licence-exempt use. However, the possibility of using the interleaved spectrum was also raised.

A8.171 Stakeholders also felt that the licence-exempt spectrum could be used as a test-bed for new services and equipment that could later be used for other services.

A8.172 In the stakeholder engagement work, some interviewees believed that WiFi and PMSE could share the interleaved spectrum without causing major interference problems.

A8.173 Responses to Ofcom's consultation on the Spectrum Framework Review also showed that there was interest among stakeholders in using UHF spectrum for low power, licence-exempt use.

Demand analysis

A8.174 The UHF spectrum could be used for a variety of low power use including: wireless 'last-mile' applications, in-house entertainment networks, safety-of-life applications, transport congestion alleviation, automated buildings, RFIDs, medical sensors, and wireless broadband. However, the demand for these uses is currently highly uncertain.

A8.175 The United States are assessing whether to authorise licence-exempt use of frequencies in the terrestrial television band, creating a potentially large market with standards that could reduce costs and resolve design issues for similar equipment in the UK. However, it is worth noting that the US proposal is for technology that can co-exist with the current use for television broadcasting. In the case of available UHF spectrum in the UK, the licensed use of either cleared or interleaved spectrum is not yet known, so technological compatibility for low power uses in these bands is similarly not known.

Economic modelling

A8.176 At the present time, estimates of private value available for this use are likely to be extremely uncertain. However, our market research has identified that there is potentially high consumer value from low power uses such as home hubs.

A8.177 Low power uses can allow a great many different users to make use of one or more frequencies in a defined band. Examples would include car alarms, wireless burglar alarms, wireless doorbells and radio frequency identification (RFID) tags on items in shops. This use can be a very valuable use of spectrum.

A8.178 In addition, it has been suggested that the availability of spectrum for low power uses on a licence-exempt basis can act as a spur to innovation. Quantifying the value to society of such innovation is highly uncertain. If innovation does occur and results in the development of new mass market technologies this can potentially generate producer and consumer value in the order of billions of pounds.

A8.179 However, a key question which needs to be assessed before we can identify the potential total value to society which could be generated from the use of UHF spectrum of low power licence-exempt use is what is the *incremental* value generated by the use of this spectrum over other alternative spectrum bands. As discussed in the section on technical limitations above, there are a number of reasons why this spectrum may be particularly unattractive for low power licence-exempt use (the relatively long distances which even low power signals carry, depending upon the power levels used, and the limitation on data rates imposed by the available bandwidth).

A8.180 Our consultants have given consideration to whether the incremental private consumer value of low power use could be greater than the opportunity cost of making spectrum available on a licence-exempt basis. The result of this assessment is the value generated is unlikely to be greater than opportunity costs. The result of this work can be found at http://www.ofcom.org.uk/consult/condocs/ddr/report_analysys/

A8.181 There might be broader social values generated by one or more low power applications. For example, if the technology is affordable and easily available more people might be able to employ wireless networks at home. Wireless home hubs could be considered to have a positive social contribution in broadening access and improving quality of life.

A8.182 However, apart from last-mile connectivity, which could enable increased access (but which Ofcom does not consider a strong candidate for licence-exempt use), other social benefits are unlikely to be large compared with the private benefits to consumers from having home wireless networks. The market research we have commissioned supports this as it suggests that, at least for the moment, wireless home networks are not perceived to have a high value to society.

A8.183 We do not therefore consider the arguments for market failure driven by broader social benefits to be particularly strong in relation to this group of uses, in comparison with alternative uses.

Assessment of case for intervention

A8.184 The following paragraphs assess each of the possible arguments for intervention outlined above, based on the evidence collected in the DDR. This analysis seeks to establish whether there is reason to believe that the factors identified would, in fact, mean that a market-based approach to the award of the available UHF spectrum would be likely to result in a suboptimal outcome for society.

A8.185 This section does not attempt to assess the benefits and costs of any potential remedies; nor does it discuss whether these remedies would be an appropriate solution to any problems identified. These issues are covered in a separate section.

A8.186 The current population of low power users encompasses individual households, retailers and logistic chains, and broadband providers among others. These are

potentially extremely numerous and are engaged in very different activities from one another, suggesting that co-ordination would not come readily to them.

A8.187 Low power uses are often non-rivalrous, that is where use by one person does not interfere with use by another person in reasonably close proximity. Using very low power transmitters is only one way of avoiding interference with users in close proximity. Technology exists today, with more in development, that enables users to occupy the same spectrum bands (or groups of bands) without interfering with other devices using the same bands nearby, at slightly higher power levels.

A8.188 The first type of transaction costs potentially leading to market failure – a large number of disparate users – is therefore faced by most if not all low power uses.

A8.189 The second type of cost – that some users can free-ride, owing to their ability to use spectrum in a non-rivalrous way – might be met by some proposed uses. However, at this time, there is no way to be certain that all uses in prospect would be vulnerable to free-riding for this reason.

A8.190 It is possible that some low power uses are vulnerable to market failure resulting from transaction costs, but that others are not.

A8.191 The arguments for market failure depend critically on a number of factors unknown at this stage:

- the likely technologies;
- the demand for them; and
- the incremental total value to society available from deploying them in this spectrum rather than somewhere else, (if relevant compared with the incremental private value).

A8.192 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 the available UHF 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 that the high transaction costs in this causing market could lead to market failure in the award of the spectrum. 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.

A8.193 Therefore, Ofcom considers the case for market failure has not yet been made sufficiently for us to propose an intervention in a market-led award of spectrum. However, the case for market failure, and the corresponding case for intervention, is still open.

A8.194 In addition to the key factors under “economic analysis” above, any consideration of intervention would depend on:

- the opportunity cost of the spectrum required; and
- the availability of intervention options at reasonable cost, and carrying reasonable levels of risk.

Opportunity cost of spectrum

A8.195 The opportunity cost of making spectrum available for low power uses will depend upon how much spectrum is required and where in the spectrum band the spectrum is located. The amount of spectrum required will depend upon the data rate required by the applications to be exempted. If the data rates are low the spectrum requirement will be limited (1 - 3 channels). However, if high data rates were required, significantly more spectrum may be required. As with any intervention, the opportunity cost rises as the number of channels claimed for licence-exempt use increases. The opportunity cost of even two channels could be significant.

Potential remedies, benefits and costs

A8.196 Option 1: auction the spectrum with no intervention. To the extent that the most likely, highest-value to society low power uses are not subject to risks of market failure, this option has no costs.

A8.197 Option 2: reserve some spectrum for low power use, on a licence-exempt basis. Where use is truly non-rivalrous, licensing use leads to inefficiency, as people who could use the spectrum, generating benefits for themselves at no cost to others, may be excluded from the spectrum. Making access free and available on demand maximises the number of users who can benefit. Because access to licence-exempt spectrum has no cost, innovations can be developed and tested more easily without any need to invest in spectrum, or to obtain a Non-Operational licence.

A8.198 However, this option has an up-front opportunity cost, equal to the value to society of the next-highest-value use of the channel or channels that are reserved for licence-exempt use (plus any other uses excluded from adjacent channels by this use).

A8.199 Licence-exemption also has implications for the future flexibility of the use of the spectrum, which will increase the cost of intervening. That is, if in future it becomes clear that a different, licensed use of the spectrum would generate higher total benefits, there is no market mechanism by which the spectrum could be re-purposed for the higher total value use.

A8.200 Option 3: defer a decision on low power use until after this consultation stage. This has the benefit of improving information, for the market and Ofcom, about likely uses, their demand and their spectrum requirements.

A8.201 As with all interventions, we need to consider the potential for regulatory failure in excluding this spectrum from any auction. Regulatory failures could include:

- failure to achieve desired effect. In this case, such failure would occur if there was insufficient demand for low power use to justify the loss of an alternative service, or if the channels reserved was unsuitable for the best low power use that emerged between now and DSO;

- unintended consequences. Of those we can foresee, there is a chance of reducing incentives for providers to consider more efficient technologies, frequencies or platforms for their services. However, this is a relatively competitive market, and the promise of one or two channels of free spectrum in one country is unlikely to hold up the collective drive of the sector to improve services and drive down costs; and

- cost of delaying decision. We are not proposing to delay the award of one or more channels, simply to delay this decision, and not later than mid-2007 if possible. We consider that it should be possible for all potential users to take account of this relatively small, temporary uncertainty, in responding to our proposals in the consultation, and in taking their own plans forward between now and that date.

A8.202 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.

A8.203 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.

A8.204 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. But we would be interested in views on the option of deliberately holding some spectrum back from award.

Ofcom's proposal

A8.205 We propose to defer final judgement on whether or not to reserve some additional spectrum for low power applications. During the consultation period we plan to gather additional information, with the intention of reaching a decision in time for the statement following this consultation.

A8.206 We would therefore like to invite representations from interested parties, in particular information about:

- technology/technological standards expected to be used;
- suitability of alternative spectrum bands (eg 2.4GHZ, 5GHz, etc) for similar services; and
- spectrum requirement and level of service (eg data speeds) that could be delivered using the bandwidth identified.

A8.207 We would also like to receive views on whether it would be desirable to hold back some spectrum from award with a view to its potential use for future innovation.

Local TV on DTT

Summary

A8.208 Set out below is a summary of the result of our assessment against each of the four elements which need to be considered to allow an assessment of whether intervention is justified to resolve a risk of market failure (as set out in Annex 7 above).

A8.209 Further detail on these potential market failures and our assessment against each of the four elements is provided in the following paragraphs.

Figure 8.4 Summary of application of analytical framework to local TV on DTT

Identification of market failure argument	Potential co-ordination problem could result in local TV operators not being able to acquire spectrum even if they have the highest aggregate value	Broader social values of local television may be high and are not factored into willingness to pay for spectrum	Advertiser funded business model may result in producer value (and hence willingness to pay for spectrum) under-representing total value to society
Assessment of risk of market failure	Demand for spectrum from local operators is uncertain, but they are likely to face difficulties coordinating a bid if spectrum is only available on a national basis	Some evidence that absolute level of broader social value could be high, although not clear that this is sufficiently different to the value generated by other services to result in a market failure. Additionally, the incremental broader social value generated from using spectrum for this service is less than the absolute given the potential for local TV on other platforms or provision via the BBC	Evidence is unclear, but there is some evidence to suggest that ad-funded model can extract sufficient consumer value. If it does not, this affects all scarce inputs, not just spectrum
Options for intervention and opportunity cost of spectrum	Option 1. Direct grant of spectrum - potentially high cost if local operators do not emerge and other possible uses are excluded Option 2. Financial and institutional framework to alow acquisition of spectrum if this is best use of resources available - cost could be high depending on scale of intervention Option 3. Use packaging and auction design to remove market failure risks - opportunity cost likely to be low, if limited to ensuring packaging allows local TV bidders to reflect their value		
Assessment of risk of regulatory failure	Option 1. Direct grant of spectrum - high local TV may not become established despite access to spectrum and other uses could be excluded, poor incentives for eficient use; lack of flexibility Option 2. Financial and institutional framework to alow acquisition of spectrum if this is best use of resources available – low as regulatory intervention minimised Option 3. Use packaging and auction design to remove market failure risks: low, low risk of excluding other uses		
Conclusion	Interleaved spectrum should be packaged in way suitable for use by local TV	Interleaved spectrum should be packaged in way suitable for use by local TV; public funding from local, regional or national agencies may be required to secure broader social value	No intervention required

Description of service

A8.210 Local content services refer to both linear and non-linear audio-visual services targeted at particular geographic communities, usually smaller than existing TV regions, and potentially as small as a particular neighbourhood or even a single estate. They can use terrestrial broadcasting as their means of distribution, but need not; providers are increasingly exploring the potential for broadband, cable and even satellite as alternative means of delivery.

A8.211 Local services were launched on analogue television in some localities under the Restricted Service Licence (RSL) regime, introduced in the 1996 Broadcasting Act. This was designed to make available 'spare' frequencies that were not being used at the time in particular parts of the UK, but were not available across the whole country. They were intended from the outset to be short-term licences, because many of the licensed services used frequencies for which there were more permanent longer-term plans, including for digital services. Ofcom has offered the remaining active RSL operators the option to extend their licences until the start of the switchover period in their region, but those licences will not continue into a digital environment, and no new licences for analogue local services will be awarded.

A8.212 More recently, a number of providers have begun to explore the possibilities of broadband for delivering local audio-visual and interactive services. These services exploit the capability of the internet to target localities of any size, to enable users to participate and distribute their own content and to deliver interactive as well as linear services.

A8.213 A number of stakeholders in the voluntary, commercial and public sectors have expressed interest in the potential to use the available UHF spectrum to deliver digital TV tailored to specific local areas. Ofcom's *Digital Local* report, published in January 2006, set out some of the technical options and provided a preliminary assessment of their advantages and disadvantages.

A8.214 Since publication of that report, Ofcom has carried out further research into audience attitudes towards local services, as well as more detailed technical evaluation of the possibilities, under the auspices of the DDR. This research, which is discussed in more detail below, has confirmed our initial findings that local services could deliver value to consumers and citizens, and that it is feasible to deliver local services on the DTT platform, although the different technical possibilities have very different benefits and costs.

A8.215 The available UHF spectrum is particularly suitable for local DTT because televisions and aerials are already tuned, or capable of being tuned, to the frequencies likely to be used. However a digital environment differs in one particularly significant way from the analogue world: DTT services rely on an Electronic Programme Guide (EPG) to help viewers navigate to the channels and content they want. For local TV to be a real possibility, it must be possible to integrate information about local services into the EPG, and this may be costly, depending on which technical solution is adopted.

A8.216 Local DTT would not need spectrum available on a national basis. As far as the DDR is concerned, it could be delivered in one of two ways: using capacity on a hypothetical new national DTT multiplex, in the cleared spectrum; or on separate local multiplexes in the interleaved spectrum. Although not relevant to the DDR, it is

worth noting that it would also be possible for local TV services to be offered using the 6 existing DTT multiplexes.

A8.217 Using a national multiplex, delivering local content services would require agreeing 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). Viewers would receive the local service along with the other, national, services on the multiplex and therefore would not need to acquire new aerials, or reposition their existing aerial, to receive the local service.

A8.218 Alternatively, local service providers or a multiplex operator acting on their behalf could acquire frequencies in the interleaved spectrum. Ease of access by viewers would depend on whether interleaved frequencies available in their area were in the same aerial group as the frequencies used by the national multiplexes in that area, and whether the local service was broadcast from the same transmitter as the national multiplexes.

A8.219 As mentioned above,there is a third option, which is for local operators to acquire capacity on one of the existing national multiplexes, the coverage of which will significantly increase at switchover. This option is not discussed in detail, since it does not relate to the reuse of spectrum released at switchover; but as the *Digital Local* report pointed out, there is no regulatory obstacle to prevent local operators from bidding for capacity on one of the commercial multiplexes as it becomes available, or from approaching the BBC to discuss the possibility of using any spare capacity on its multiplexes. There is no reason capacity on a new multiplex would be more attractive for local TV than capacity on one or more of the existing multiplexes.

A8.220 Finally, some local operators may choose not to use terrestrial transmission as a method of delivery of their services, because of its relative inflexibility and cost compared to other delivery channels such as broadband. The economic analysis carried out for the *Digital Local* report suggested that DTT offered most benefits to potential local TV providers in larger urban areas, where the size of the market justified both use of transmitters that typically cover a large area, and the costs associated with access to those transmitters and to frequencies for broadcasting.

A8.221 In the following sub-sections we first of all set out the potential market failure arguments which may be relevant to local TV and then cover in turn the evidence which is relevant when considering these arguments, our assessment of the validity of the market failure arguments, the opportunity cost of intervention via spectrum, and finally, the potential remedies for these market-failure issues (including an assessment of their benefits and cost and regulatory failures). Finally, we set out our conclusion in relation to the potential market failure arguments.

Possible arguments for intervention

A8.222 If the available UHF spectrum were to be awarded through a market-based process, would there be any risk that there would be less local TV on DTT than would be socially optimal? Local providers would be free to participate in any auction for the spectrum, or to bid for capacity on any new DTT multiplex that was established. Alternatively they could signal their interest to potential third-party bidders for spectrum for DTT capacity, such as a multiplex operator, to help support the business case for the operator's bid.

A8.223 Of course, the amounts local operators might have to pay for capacity could be substantial. But this would simply reflect the market price for the bandwidth they need, and the number of alternative demands for that bandwidth. They might find it difficult to raise the funds required, but absent market failures which could result in the willingness to pay for spectrum not reflecting the value to consumers and citizens (potential risks of which are discussed later), if this were the case, this would tend to cast doubt on their proposed business model, rather than the method by which they acquire the resources they need. If their business model does not enable them to afford to pay for spectrum, then this suggests that there are more valuable uses for that spectrum, that customers – whether they be viewers, service users or advertisers – are prepared to pay more for. Similarly, local operators might find it difficult to raise finance in capital markets, because their business model is as yet unproven. But, absent market failures, this is the same as for any start-up company, and the onus is on the operators to demonstrate that they have the potential to make a sufficiently attractive return to justify the risk faced by start-up investors.

A8.224 Therefore, to the extent that local TV is a viable commercial concern, it might seem that there is no case for intervention in the award of spectrum to support it. However, there are three risks of market failures which this analysis does not take into account.

A8.225 The first is that local operators may face difficulties coordinating a bid for capacity if it is only available on a national basis. The local content sector could be very fragmented, with different providers serving different communities and using different funding models. In many areas providers might not yet exist. As a result, even if local content did represent the most efficient use of some parts of the spectrum, and could afford in aggregate to pay most for it, it might prove difficult for operators to mount an aggregated bid for nationwide capacity.

A8.226 The second factor is the potential provision of broader social value by local content. The *Digital Local* report suggested that local content could serve a number of public purposes, including providing local news and information, community involvement and participation in civic life, strengthening of community identities and improving access to local services. Analysis carried out for the DDR supports this, identifying a number of ways in which local content could deliver broader social value.

A8.227 This broader social value may not be taken into account by advertisers or potential investors in local services, since it does not directly deliver commercial returns. In fact content that delivers public purposes could in some cases be in tension with commercial interests if it displaces more overtly commercial content, such as promotion of local services and events, classified advertising or local shopping services. As a result, there could be a disparity between the total value to society provided by local DTT in the released spectrum and local providers' willingness to pay for that spectrum.

A8.228 The third factor is that if local TV services are offered free-to-view, the willingness to pay for spectrum may under-represent the consumer value generated from the service if the value generated from the launch of local TV on free-to-view on DTT is particularly high. This is because the advertiser revenues which are generated may not adequately reflect the high consumer value.

Evidence gathered by the DDR

Technical analysis

A8.229 There is a range of technical options for the delivery of local TV content. The two main alternatives proposed by stakeholders are to use capacity on an existing or new national multiplex, using add/drop arrangements, or to establish a series of dedicated local TV multiplexes at particular locations. Ofcom has commissioned a technical assessment of the second of these options (this analysis is presented in the report from LS telcom which can be found at http://www.ofcom.org.uk/consult/condocs/ddr/reports/, and which is set out in summary form in Annex 11).

A8.230 The first option is the add/drop approach, in which local services are carried alongside national services on a national multiplex. This approach is likely to maximise coverage of local TV, since coverage would match the coverage of the multiplex as a whole, subject to local services existing at each locality. It would also mean that all DTT receivers would be able to receive it in the area of their local service without the need for retuning.

A8.231 However, this approach also has significant disadvantages. Most seriously, only one local service could be carried per multiplex on each transmitter, and therefore in larger transmitter areas (including London, the northwest of England and Birmingham) a single service would cover the whole area – which would be closer in size to an existing TV region than a truly local service. Even in smaller transmitter areas, in many cases the area covered by the transmitter might not appropriately map onto real local communities. Some local TV stakeholders have proposed that several local services could be provided from a single transmitter by making capacity available on more than one multiplex carried on that transmitter, but this would increase the opportunity and deployment costs of local TV in direct proportion to the number of slots taken up on the national multiplexes.

A8.232 The add/drop proposal also presents challenges with respect to the distribution of Service Information (SI) for local services. SI is broadcast by digital broadcasters alongside programme services and contains information about the service itself, other services carried on the same multiplex and current and future programmes shown by those services. It is essential to the effective operating of digital receivers, since it helps the receiver 'sort out' one service from the others within a multiplex, and it is also used to provide the common 7-day EPG used by the majority of receivers.

A8.233 For local TV programme information to be included in EPGs, each local TV service would need to provide its own SI data for each service being carried and arrange for cross carriage f this data on other multiplexes broadcast from that site. These costs would need to be met by each local provider, and could be greater if there were insufficient capacity in the central SI collator to incorporate the additional information streams.

A8.234 The second option is to operate one or more dedicated local TV multiplexes in each area in which there is demand for local TV. These local TV multiplexes could be launched using either cleared or interleaved spectrum. Work commissioned by Ofcom found that sufficient spare frequencies will exist in the interleaved spectrum after switchover to deliver at least one local TV multiplex at 40 of the 50 main DTT transmitter sites, enabling 60-70% of homes to receive a local TV service. It is likely that frequencies would also be available at significantly more sites than this,

although we have only carried out the necessary modelling for the main transmitter sites at this stage. The opportunity to use the interleaved spectrum to provide local TV is therefore significant.

A8.235 The interleaved spectrum enables more targeted services to be provided, because they would not need to use the same antennas as the national multiplexes. Therefore they could use directional antennas, which enable different services targeting different areas to be broadcast using the same frequency, at the same site, but in different directions. At the Sandy Heath transmitter, for example, directional antennas could be used to transmit three separate local services to Milton Keynes, Bedford and Cambridge. The use of directional antennas enables several services to be broadcast on one frequency and transmission power to be boosted since the breadth of the area covered by the signal, and the consequent risk of interference, are reduced. This option is not available under the add/drop proposal.

A8.236 For these reasons, it seems that the operation of dedicated local TV multiplexes would be a better route to achieve widespread coverage and the ability to use spectrum flexibly and efficiently by providing targeted services where there is demand for them.

A8.237 There will be similar issues concerning the origiantion and carriage of SI with these services and other multiplexes as were discussed above.

A8.238 However, there are other possible uses of the interleaved spectrum, which is a valuable resource. These include PMSE, other potential low power applications, and use for an additional, limited capacity quasi-national DTT multiplex. An operator could aggregate the interleaved frequencies into a single multiplex covering a number of regions, and use it to deliver a quasi-national service. Use for applications such as mobile multimedia would also be technically possible, if less likely.

Market research

A8.239 Evidence from the market research undertaken for the DDR suggests that many viewers do attach value to local TV on DTT, although it is less important to them than additional national standard definition channels. The primary benefit of local TV was seen to be local news and travel updates.

A8.240 Local TV services were also seen as potentially valuable to society more broadly. When asked to rate the importance to society of a number of attributes of new digital services, many of the most highly-rated attributes related to local issues, including that local news, information and other programmes about community, people and events should be available on TV.

A8.241 However, the evidence on this point is ambiguous. 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.

A8.242 Note that an implication of this is that it may be unnecessary and unrealistic to expect universal coverage for local TV. Many areas were seen as too small or too

dispersed for there to be significant demand for, or social benefits provided by, a 'local' service.

Stakeholder engagement

A8.243 Organisations and individuals involved in local content, or promoting its potential role as a form of public service broadcasting in a digital environment, have been heavily involved in the DDR process. Potential stakeholders include a wide range of bodies, including existing local TV operators, national PSB broadcasters, community media organisations, regeneration bodies, local public service providers and other local media providers.

A8.244 Stakeholders showed interest in local TV, not only in major cities (where it may be commercially viable) but also in more rural areas. Some advocated a community approach to local media, with the emphasis on small-scale, community-led initiatives often focusing on delivering broader social value in relatively deprived areas. Others prefer a commercial model, particularly in larger urban areas.

A8.245 Stakeholders argue that there are no credible alternatives to provision of local TV in the cleared spectrum or on existing multiplexes, because national DTT is the only way to ensure the universal availability of local content. They argue that there are no credible alternative spectrum bands given that deployment to new bands requires that new aerials be installed in viewers' homes.

A8.246 Local content providers argue that their public benefit was recognised by Ofcom in the *Digital Local* study. That report identified that local TV can deliver a number of social benefits, including:

- diverse programming tailored to the local community;
- widening the community's involvement in broadcasting; and
- creating jobs in the cultural and media industries.

A8.247 These stakeholders expressed concern that an auction of the available UHF spectrum would favour national broadcasters. They point out that the majority of potential stakeholders are currently 'dormant,' and thus cannot compete with national broadcasters. They believe that an award should be based on social benefits rather than a market-led approach.

Demand analysis

A8.248 At present, the market for local content services is relatively small – there are a few analogue RSL operators and a variety of services available on broadband, mostly with a community or public service focus. However, this is a time of rapid change in the sector. The BBC and ITV have both carried out trials of local services, and a number of local newspaper groups are experimenting initially with placing video on their websites.

A8.249 Market modelling carried out for the *Digital Local* report suggested that commercially-funded local services could be sustainable in a digital environment, using a free-to-view model. Commercial services would be likely to use a range of distribution platforms to maximise reach and impact, including broadband, cable and – in some areas – DTT and satellite.

A8.250 However commercial services are only likely to be viable in larger metropolitan areas, with large, relatively young and affluent populations. Even these services are likely to have limited scope for commissioning high-quality original local content that could help deliver the potential broader social value of local services.

A8.251 For these reasons, the *Digital Local* report concluded that services in smaller or more rural areas, or that made a significant contribution to delivering public purposes, were likely to require public support and funding from one source or another.

A8.252 One outstanding question is the impact of any future BBC services on the potential market for local TV. The BBC has set out plans for a network of 50-60 local services across the UK, based largely on existing local radio coverage areas, offering audiences local news and information throughout the day.

A8.253 Some stakeholders have expressed concern that the BBC could prevent emerging commercial ventures from achieving critical mass and developing a sustainable proposition in this relatively new market. On the other hand, if the BBC does develop local services, it is possible that these will deliver much of the broader social value offered by local TV, weakening one possible argument for intervention in the award of the available UHF spectrum to support local TV.

A8.254 It is too early to be certain about whether the BBC's proposed services will, in fact, go ahead; and if they do, what impact they might have, if any, on commercial and community local TV services. Under the new governance arrangements for the BBC, any new local content service would be subject to a public value test, incorporating a market impact assessment carried out by Ofcom. If these requirements were met, we proposed in *Digital Local* that there should be further debate about the role of the BBC in this emerging area, including the possibility of partnerships between the BBC and other providers.

Economic modelling

A8.255 Our modelling suggests that there is considerable uncertainty over the consumer value of local TV. However, it is plausible that there will be sufficient consumer demand for local content for commercial services to be viable in larger, metropolitan markets. Consequently, the value of local TV on DTT to service providers could be sufficient in those markets to win spectrum in a market-based approach, particularly in areas where there are relatively few alternative uses for the spectrum.

A8.256 However in other areas of the UK, providers' willingness to pay for spectrum may be generally relatively low, compared to consumer and citizen demand for local content. There is evidence to suggest two possible reasons for this.

A8.257 First, there may be consumer and citizen interest in local content, but our qualitative research suggests that viewers would not expect to watch very much local TV – perhaps a few minutes every day, to catch up with local news, but not significant volumes every day. But advertiser demand for airtime is a function of the amount of viewing, as well as reach – local services might reach a relatively high proportion of the population, but if they only watch for a few minutes each day, the overall share of viewing of local services – and advertiser demand for airtime on those services – will be lower than for some other services with a similar reach, but a higher volume of viewing. In this situation, if consumer interest is sufficiently high, a subscription model may be more appropriate than advertiser funding.

A8.258 Second, the broader social value generated by this use could be relatively high compared to other potential uses of the available UHF spectrum. If this is the case, the total benefits generated by local content services may not be fully reflected in a market-based award process. However, there are a number of reasons why the level of broader social value generated may not be significantly different from that generated by other uses, and hence would be unlikely to result in a market failure in the award of the available UHF spectrum.

- The broader social value identified was for local TV on all platforms, and it is unclear what level of broader social value is specifically offered by provision on DTT. Providers are increasingly turning to broadband, with its combination of low distribution costs, flexibility to target very specific audiences and interactive capabilities, to deliver local content services. Digital satellite and cable are also being explored as possibilities. It is therefore likely that these platforms will provide at least some of the broader social value associated with local content, and that the incremental value provided by local DTT would be somewhat less than the total broader social value identified. Nonetheless, DTT will offer a level of reach that no other platform currently can, and for that reason is likely to continue to be important to potential providers as part of a mix of distribution techniques in a digital environment.

- It is possible that some viewers who express interest in local services would, in reality, not watch them, because of the high and growing degree of competition for their attention. In particular, if the quality of content that can be afforded by local providers is not as high as for national TV services, some potential viewers may be put off. In our qualitative research, some viewers expressed concern that local services might be too local, and would not have sufficient content to retain their attention on a regular basis. If this were the case, the broader social value generated could well be less than that suggested by our modelling.

- Finally, the experience of the internet suggests that while geographic communities remain important, other kinds of interest-, faith- or lifestyle-driven communities are also attractive to consumers and citizens and offer many of the same kinds of benefits as local communities. Over time, it is possible that we will see weakening of local bonds and a growth in the popularity of these kinds of community, which might result in demand for local TV declining.

Assessment of the case for intervention

A8.259 The following paragraphs assess each of the possible arguments for intervention outlined above, based on the evidence collected in the DDR. This analysis seeks to establish whether there is reason to believe that the factors identified would, in fact, mean that a market-based approach to the award of the available UHF spectrum would be likely to result in a suboptimal outcome for society.

A8.260 This section does not attempt to assess the benefits and costs of any potential remedies; nor does it discuss whether these remedies would be an appropriate solution to any problems identified. These issues are covered in a separate section.

A8.261 Our assessment against each of the potential market failure arguments is as follows:

A8.262 The risk of **co-ordination difficulties** between independent local operators may be significant, particularly given the early stage of development of the local TV sector. However it is important to note that the extent of demand for capacity for local TV

remains uncertain. In many areas where local services could theoretically develop, there may never be an operator who wishes to set one up in reality.

A8.263 The evidence regarding the **broader social value** of local content is suggestive. However, again it is not certain. Much depends on whether viewers do, in practice, want to watch local content, and whether broadband services prove more capable of meeting viewers' needs than linear broadcast services.

A8.264 In relation to the potential for a market failure to occur if local content is offered via a **free-to-view rather than a subscription model**, we refer back to our discussion of this market failure issue in paragraphs 8.388 to 8.397 below. To summarise, whilst we believe that this market failure could occur, in practice we consider that there are a number of reasons why the effect of this market failure may be limited and, further to this, there are number of reasons why intervention to secure spectrum for free-to-view services is likely to be inappropriate and ineffective.

A8.265 Overall, we believe that independent local TV operators could face co-ordination risks if they need to combine their private value to bid for national spectrum packages. However, there is uncertainty over whether the broader social value of local TV is sufficient to result in a market failure in the award of the available UHF spectrum. Finally, whilst there is in theory a market failure concern in relation to the consumer value extracted by free-to-view broadcasting, the significance of this effect is unclear and the magnitude of the effect could be limited.

Opportunity cost of spectrum

A8.266 The opportunity costs of spectrum for local TV will vary according to the technical approach adopted. Using capacity on a national multiplex could be very costly – if a new multiplex were developed using cleared channels the opportunity cost of even a single slot on tht multiplex is likely to be relatively high. If more slots were required to deliver multiple services from a single transmitter, the costs would increase in proportion.

A8.267 The opportunity costs of using the interleaved spectrum are considerably lower, although they will vary from location to location. However, the interleaved spectrum is still a valuable resource, and has a number of alternative uses. These include PMSE, other low power applications, and a quasi-national DTT multiplex.

Potential remedies, benefits and costs

A8.268 We have concluded that the main market failure risk in relation to local TV is the ability of local TV providers to coordinate a bid for spectrum. Additionally, there is a risk that broader social value generated by local TV could result in a market failure. However, the evidence on this issue is uncertain. We discuss the potential remedies to these two risks of market failure below.

A8.269 There are a number of possible forms of intervention which could in principle remedy these market failures. These are discussed under the following three headings: direct grant of spectrum, providing assistance to bidders in an award and using auction design to reduce assymetries between bidders.

A8.270 A direct grant of spectrum for local TV could involve either set aside capacity on a new national DTT multiplex in the cleared channels, enabling local services to be launched in every area covered by that multiplex, or setting aside frequencies in the interleaved spectrum.

A8.271 We do not believe that the option of setting aside capacity on a new national DTT multiplex is a viable option. There is insufficient evidence to justify intervention on this scale, because the costs are high and the benefits very uncertain. The opportunity cost of this capacity would be relatively high, since it could be used to launch additional national commercial or PSB channels in SD or HD, and the extent of demand for local TV remains uncertain. Particularly, it is unclear that viewers in every location would want or need a local TV service. As a result, capacity could be wasted in some areas. Moreover, the deployment costs are likely to be high, because of the difficulties associated with inserting Service Information for local services into viewers' EPGs. Finally, this option relies on the creation of one or more new DTT multiplexes in the available UHF spectrum, which is not guaranteed; as set out above, we do not believe there is sufficient evidence to warrant intervention to secure this.

A8.272 The option of setting aside frequencies in the interleaved spectrum has opportunity costs which would be lower, particularly in areas where interleaved frequencies are available for which there is little demand from alternative uses. However, local TV is not the only possible use of the interleaved frequencies, and we do not know that local TV would necessarily be the highest value use of the spectrum for society; over time future uses may emerge that represent higher value. Administratively awarding spectrum would create an inappropriate incentive to use DTT, when our economic analysis suggests that broadband and other platforms could offer more cost-effective ways of delivering services in some areas and it would also not create incentives to use spectrum efficiently. Moreover, awarding spectrum may not be sufficient to ensure that services delivering broader social value are established – they may still need additional public funding even if frequencies were made available at zero cost. In this case we might intervene to make spectrum available but still not achieve the proposed goal, if additional funding is not available.

A8.273 The second remedy option is to ensure a funding and institutional framework is in place to allow acquisition of spectrum if this is the best use of resources. This is unlikely to be an effective solution to the risk of market failure arising from co-ordination difficulties as the provision of assistance (through for example public funding) does not reduce the co-ordination costs. Hence, this is unlikely to be the most cost-efficient resolution to the problem when compared to using auction design to resolve this problem (as discussed below). It also raises the problem of misaligned incentives discussed above.

A8.274 For the potential broader social value market failure, this form of intervention may be effective. The justification for this intervention will however, depend upon the magnitude of the broader social values which may be generated, which is uncertain. This approach to remedying a market failure caused by the presence of broader social values is likely to minimise the risk of regulatory failures in relation to this form of market failure, as it maximises the future flexibility of the use of the spectrum, minimises the risk of getting the intervention wrong (ie precluding other higher value uses of the spectrum for society) and provides incentives for the efficient use of spectrum. However, in relation to regulatory failure it is worth noting that this intervention may be ineffective if the co-ordination cost risk of market failure is not also addressed.

A8.275 The third remedy option is to use auction design and packaging to resolve market failure risks. In the case of the award of the UHF spectrum this would suggest that the packaging of interleaved spectrum should include packages that are suitable for possible local TV operators, hence minimising the impact of transaction costs on the ability of local TV operators to bid for spectrum. This should allow local

operators to bid for spectrum in most metropolitan areas, where our economic analysis suggests that local DTT services are most likely to be commercially viable. In more rural areas, where there is less demand for spectrum from PMSE and other uses, local TV operators are likely to find that the cost of spectrum is low. In addition, this would provide opportunities for not-for-profit local TV operators to bid for spectrum to secure broader social values if funding were made available to support this activity.

A8.276 This approach has the advantage that frequencies are only used where there are operators willing to use them, and that other uses are not precluded if they turn out to be more valuable to society than local TV, taking both consumer and broader social value into account.

A8.277 However, it does have some disadvantages. The main disadvantage is that this approach does not in itself guarantee the delivery of the potential broader social value of local TV (even if additional funding is provided to support local TV operators), since the spectrum would go to the highest bidder. If there were a straight competition between a commercial local TV provider and a community service, it is likely that the commercial service would be better funded and therefore more likely to secure the spectrum. It may be that commercial providers would in reality deliver most of the broader social value, if doing so coincides with their commercial drivers; for example, our analysis suggests that most broader social value is associated with provision of local news, which is likely to be the cornerstone of any commercial provider's service. But this is not guaranteed to be the case.

A8.278 The other disadvantage is that local TV would not be universally available on DTT under this model. However, our analysis suggests that not every locality needs a local TV service, but that in most towns and cities, where demand for local TV is likely to be greatest, interleaved frequencies would be available. Smaller towns and villages are often served by a transmitter covering a very large area, where genuinely local TV over DTT is not expected to be viable, so it may be that the number of areas where local DTT services would have relevance, but where interleaved frequencies are not available, is relatively small.

Ofcom's proposal

A8.279 We propose to include packages of the interleaved spectrum that are suitable for use by local providers, but not to predetermine their use for that purpose. This combines flexibility in the use of the spectrum, and avoids potential inefficiency, with an approach that does not prevent or unduly disadvantage independent local TV operators from acquiring spectrum for their particular service.

A8.280 The key disadvantage of this approach is that it does not guarantee delivery of the potential broader social value of local TV. We suggest that the most appropriate form of additional public intervention to achieve this would be for local funding bodies (such as for example, regional development agencies, local authorities and community or regeneration groups) to contribute to bids for spectrum by providers of services that do deliver broader social value, as well as to the costs of any other resources those providers might require to meet public purposes.

Mobile Broadband

Summary

A8.281 Set out below is a summary of the result of our assessment against each of the four elements which need to be considered to allow an assessment of whether intervention is justified to resolve a risk of market failure (as set out in Annex 7 above).

A8.282 Further detail on these potential market failures and our assessment against each of the four elements is provided in the following paragraphs.

Figure 8.5 Summary of application of analytical framework to mobile broadband

Identification of market failure argument	Broader social value generated from the universal access of mobile broadband may not be fully reflected in a bid in an auction, owing to relatively high levels of broader social value generated by this service when compared to other potential uses of the available UHF spectrum
Assessment of risk of market failure	The risk of this market failure occuring is assessed to be low There is some evidence of relatively high levels of broader social value for universal access to this service. However, there is significant uncertainty over a) the proportion of this value generated by *mobile* broadband and b) the requirement for UHF spectrum to realise this value
Options for intervention and opportunity cost of spectrum	Option 1. A direct grant of spectrum - could resolve this issue, but this would be at a high opportunity cost given the amount of spectrum which may be required Option 2. Intervention via auction design - unlikely to be effective in resolving this market failure. The use of bidder credits could potentially resolve this issue, but as with the direct grant of spectrum, the opportunity cost of this may be high given the amount of spectrum required Option 3. Financial and institutional framework to allow acquistion of spectrum if this is best use of resources available - this would be the most effective remedy for this potential market failure (if it arises) as this would allow operators to make decisions over the most efficient means of delivering this social goal and the opportunity cost of achieving this would be transparent and evident in the award process
Assessment of risk of regulatory failure	Option 1. A direct grant of spectrum - high with a direct grant of spectrum, as this could have unintended consequences if mobile broadband does not turn out to be the highest total value use (ie use with the highest value to society) and because of the impact of a direct grant of spectrum on the incentives for the efficient use of spectrum Option 2. Intervention auction design - high with intervention via an auction, as this could have unintended consequences if the bidder credit is set too high, or fail to achieve the desired effect if the bidder credit is set too low, and it could have unintended consequences because of the impact of a bidder subsidy on the incentives for efficient use of spectrum Option 3. Financial and institutional framework to allow acquisition of spectrum if this is best use of resources available – low, regulatory intervention minimised
Conclusion	No intervention required currently, spectrum to be packaged to allow mobile broadband to be one possible use of UHF in the future

Description of service

A8.283 The available UHF spectrum could be used to provide wireless access to broadband services. This could encompass new “broadband nodes” in rural areas where provision of broadband access via fixed (wired) networks is very expensive

on a per household basis. Additionally, it could be used to support truly mobile broadband access, from handheld and portable devices.

A8.284 The available UHF spectrum is useful for wireless access because the signal can travel relatively long distances, so that large areas can be covered at lower cost than if using higher frequency bands. Having relatively few, lower-frequency nodes would 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.

A8.285 Nationwide provision of mobile broadband using this spectrum could require up to seven of the 15 cleared national channels.

A8.286 As discussed in Section 4, 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.

Possible arguments for intervention

A8.287 The possible argument for intervention in relation to the provision of mobile broadband services relates to the broader social value which may be generated by universal coverage of this service.

A8.288 The argument is that universal availability of mobile broadband will generate broader social values (access and inclusion, quality of life and belonging to a community) which will not be reflected in the amount bid in a market based award process. The argument continues that, as a result, universal availability of this service may not be achieved, as the total benefit of using UHF spectrum (which allows greater coverage) over other available spectrum will not be reflected in decisions by operators. Hence, lower overall levels of coverage may be realised.

A8.289 It is worth noting that the incremental total value of universal availability of mobile broadband may be particularly significant in rural areas, where this may provide access to broadband where this was not already available.

Evidence gathered for the DDR

Technical analysis

A8.290 The technical analysis identified that mobile broadband is a technically plausible use of the cleared spectrum. This use would require at least 8MHz and preferably more than 30MHz of contiguous spectrum.

A8.291 However, there are likely to be co-existence issues between mobile broadband and some of the other potential uses of this spectrum, in particular DTT and mobile TV. If mobile broadband is to co-exist with such uses guard bands are likely to be required between uses. Our analysis on the requirement for guard bands is discussed in Annex 10 and in the Aegis work which is available at http://www.ofcom.org.uk/consult/condocs/ddr/report_analysys/.

A8.292 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.

Market research

A8.293 The key findings from the market research in relation to mobile broadband are summarised below.

A8.294 From a private value perspective, after price, mobility and then download speed had the greatest impact upon consumer choice of hypothetical mobile broadband packages. When ranking services in terms of their importance consumers ranked mobile broadband as roughly as important as high defintion TV services on the DTT platforn and more importantt than mobile multmedia services.

A8.295 The private value research suggested that a £5 monthly subscription was a critical price threshold for mobile broadband that would maximise revenue and penetration. Over a third of consumers claimed that they would subscribe to a mobile broadband package offering full coverage, mobility and a download speed of 8Mbps at a price of £5 per month (similar consumer values were also suggested for a 2Mbps download speed).

A8.296 When assessing the importance of services both to themselves and to society participants indicated that there was some additional value to society (ie broader social value) generated by mobile broadband services. However, the level of this uplift was not disproportionally greater to the uplift for other potential uses of the UHF spectrum. The research suggested that coverage is an important feature of a mobile broadband service which is of value to society. Whilst coverage was found to be relatively unimportant from a private value perspective, when considered from the perspective of society as a whole coverage was felt to be particularly important. The deliberative research suggested that after coverage, mobility was the most important attribute from the perspective of society.

Stakeholder engagement

A8.297 Stakeholder engagement identified the following points:

- there was interest from stakeholders in using this spectrum to offer mobile broadband services. An important driver of this was the propagation characteristics of this band which would allow operators to provide services in more rural areas at lower cost than with the other (higher frequency) spectrum available for this use;

- stakeholders expressed an interest in deploying both WiMAX and UMTS TDD technologies in this band, and hence expect to require unpaired spectrum preferably in 5 or 10MHz blocks (however there may be some flexibility on block size); and

- however, stakeholders are also interested in deploying mobile broadband services in alternative spectrum bands such as 2.6GHz.

Demand analysis

A8.298 The market analysis has identified that there is evidence of demand for access to UHF spectrum for mobile broadband use, and as such mobile broadband is a potential use of this spectrum band from a market perspective.

Economic modelling

A8.299 The private value modelling suggests that the value generated (consumer and producer value) by mobile broadband is of a comparable magnitude to the value generated by some of the other potential uses of the available UHF spectrum.

A8.300 Our assessment of external values identified that there is some evidence of potentially significant broader social values from providing universal access to mobile broadband. However, it is not clear to what extent UHF spectrum is essential to achieving this.

A8.301 The analysis undertaken by our consultants (see report available at http://www.ofcom.org.uk/consult/condocs/ddr/report_analysys/), suggested that whilst there is some evidence that the broader social value of mobile broadband relates to its mobility, it is unclear to what extent the broader societal benefits derive from access to broadband on any platform. However, they also point out that where providing spectrum for provision of wireless services is likely to be the only possible means of accessing broadband, the magnitude of benefit for those particular individuals – and broader social value - would be likely to be large, but the number of cases where this applies is likely to be small. Therefore, it is important to consider whether the benefits of broadband access per se are different from the aggregate incremental benefits associated with use of the UHF spectrum.

A8.302 Therefore, in summary, whilst the broader social value of mobile broadband, may derive in part from its mobility (and the importance of this element of the service may increase over time), it is also driven by its ability to provide broadband access where fixed line services are not available.

A8.303 However, the UHF band is only one of a number of candidate bands for deployment of this type of service, and is not necessarily the most favoured. Even if there was no wireless broadband deployed using this spectrum, it seems likely that similar provision would be made using other spectrum. Therefore, notwithstanding findings of potentially significant general broader social value associated with this service, it seems likely that incremental value will be small and not disproportionately greater than the level of broader social value generated by other potential uses of the available UHF spectrum.

Assessment of the case for intervention

A8.304 The following paragraphs assess each of the possible arguments for intervention outlined above, based on the evidence collected in the DDR. This analysis seeks to establish whether there is reason to believe that the factors identified would, in fact, mean that a market-based approach to the award of the available UHF spectrum would be likely to result in a suboptimal outcome for society.

A8.305 This section does not attempt to assess the benefits and costs of any potential remedies; nor does it discuss whether these remedies would be an appropriate solution to any problems identified. These issues are covered in a separate section.

A8.306 There is some evidence to suggest that the broader social values which are generated by mobile broadband services could be somewhat greater than the level of external value generated by some other potential uses of the available UHF spectrum. However, there are a number of reasons why the magnitude of these effects may not be significant enough to result in a market failure, and why the presence of these effects may not result in a market failure in relation to the award of the available UHF spectrum:

- the magnitude of the broader social value generated by mobile broadband is not significantly out of line with that generated by some other potential uses;

- the evidence from the market research suggests that universal availability is the main drivers of the broader social value of this service. Therefore, the incremental broader social value generated from the availability of mobile broadband, compared to the availability of broadband per se, requires further investigation;

- however, having said this, it is plausible that in the future the broader social value derived from mobility may increase, as this becomes a more commonly available service in the UK. Further to this, as standard broadband speeds increase, the limitations of wired broadband to meet these requirements may become more severe not only in rural areas. This is because wireless solutions may be the only technically feasible option for delivering high speed broadband as the distance from the exchange at which high speed fixed broadband services can be provided falls as the data speed increases;

- despite this, there are still a number of alternative options for the realisation of the broader social values identified both now and in the future (reducing the incremental broader social value of the available UHF spectrum for mobile broadband). These include the extension of coverage of fixed broadband as well as the launch of mobile and/or wireless broadband in other available spectrum bands. For example, the 2.6GHz spectrum is likely to become available in the UK ahead of the available UHF spectrum and is a band which is particularly attractive to stakeholders wishing to launch mobile broadband services (albeit less suited to rural coverage than lower frequency spectrum). Ofcom is also planning to consult in the early part of 2007 on liberalising the use of the 900 MHz and 1800 MHz bands; 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.

A8.307 Therefore, not only is it unclear whether the magnitude of the broader social value generated by mobile broadband is significant enough to result in a market failure, it is also unclear whether the award of the available UHF spectrum is relevant to the realisation of the potential broader social value available from universal access of mobile broadband service. There are alternative spectrum bands (and potentially other broadband delivery mechanisms) which may deliver these values.

A8.308 Additionally, it is not the launch of the service itself which is the driver of the broader social value, rather it is the extent of coverage achieved. Therefore, any intervention to secure these benefits would need to consider the costs of extending coverage alongside any dynamic effects of intervening to secure this (including, for example, the effects on competition and innovation).

A8.309 However, if intervention to secure universal access to mobile broadband was found to be justified, the potential costs savings from using UHF spectrum to extend coverage would be a relevant consideration. However, there is still uncertainty over the magnitude of the potential cost savings of using UHF spectrum rather than alternative (higher frequency) spectrum, as whilst the propagation characteristics of UHF spectrum make this a lower-cost alternative for achieving coverage, the technical co-existence issues which are likely to occur with the use of UHF spectrum to provide mobile broadband are likely to increase costs.

Opportunity cost of spectrum

A8.310 The opportunity cost of intervention via spectrum to make spectrum available for mobile broadband services would be relatively high. The spectrum requirements of this use are such that it would be likely to require three or more 8 MHz channels.

Potential remedies and their respective benefits and costs

A8.311 As identified above, there is insufficient evidence to suggest that the presence of potential broader social values generated by the universal availability of mobile broadband would result in an inefficient allocation of spectrum in a market-based award of the available UHF spectrum.

A8.312 Further to this, it has been identified that intervention to secure the benefits of universal access to mobile broadband services is not tied directly to the availability of UHF spectrum. The benefits would be realised by extending coverage of mobile broadband services launched in alternative bands, and may also be realised by extending the coverage of wired broadband services.

A8.313 Therefore, this suggests that if intervention was required, a direct grant of spectrum or bidder credit alone would be an ineffective means of securing the benefits, as the benefits relate to the provision of a desired level of output (universal coverage) which is not directly tied to the availability of spectrum, even though this coverage may be achieved at lower cost using UHF spectrum compared to higher frequency alternatives.

A8.314 The potential need to extend coverage beyond commercially attractive levels suggests that some level of public subsidy would be required to achieve this goal. Therefore, the provision of a public subsidy is likely to be the most effective means of intervening to achieve the universal coverage of mobile broadband services, if required, as long as the operators who may provide this service are able to take account of the relative cost of achieving this using all suitable spectrum bands and delivery mechanisms.

A8.315 Given that coverage can potentially be achieved at lower cost using UHF spectrum, the effectiveness of a public subsidy may in part depend upon the availability of this spectrum. In principle this availability could be secured by a direct grant of spectrum for mobile broadband services (alongside the provision of funding). However, the opportunity cost of this type of intervention is likely to be very high. Further to this, given the uncertainty over whether the total value of mobile broadband services is disproportionately greater than the total value to society generated by other potential uses, there is a significant risk of regulatory failure attendant on such an intervention.

A8.316 An alternative option would be to ensure that the packaging used for the available UHF spectrum does not preclude its use for mobile broadband services either at the

time of the award or in the future. The opportunity cost of this type of intervention is very low, as the market and economic analysis has already identified that mobile broadband is a potential high total value use of this spectrum (ie a use with both a high private value and a high value to society). This finding in itself suggests that intervention now may not be required in order to allow the option of using UHF spectrum to achieve universal coverage of mobile broadband services in the future, as it is plausible that some UHF spectrum will be used for mobile broadband irrespective of any future intervention.

Ofcom's proposal

A8.317 Ofcom's policy proposal in relation to mobile broadband services is to ensure that release of spectrum does not preclude potential use of spectrum for mobile broadband. Lower frequency spectrum such as this is particularly valuable for covering large areas at lower cost.

A8.318 Any policy intervention to secure universal coverage for mobile broadband raises issues that go beyond the DDR. It would require consideration of total costs (including the costs of network build and resulting operating expenditure), alongside dynamic effects on competition and innovation. As the achievement of this goal is unlikely to be directly tied to the UHF spectrum, this analysis goes beyond scope of the DDR.

A8.319 Further to this, evidence on the relevance of UHF spectrum to this issue is uncertain. There is some evidence to suggest that other delivery mechanisms such as wired broadband may bring much of the potential benefit. In addition, while there is some evidence of UHF being a low cost alternative compared to other suitable spectrum for mobile broadband services (eg 900MHz, 1800MHz, existing 3G bands, 2.6GHz), the interference constraints which this use would face when using UHF spectrum are likely to increase the cost of using this band for mobile broadband and hence may limit the extent of the cost advantage.

National DTT

Summary

A8.320 Set out below is a summary of the results of our assessment against each of the four elements which need to be considered to allow an assessment of whether intervention is justified to resolve a risk of market failure (as set out in Annex 7 above).

A8.321 There are twofiguress: the first discusses arguments related to the potential failure of markets to fully reflect the total value of additional DTT services, while the second assesses arguments related to the potential detrimental effect of a lack of additional capacity on the DTT platform. Arguments in relation to the provision of HDTV on the DTT platform are considered in the next section.

A8.322 Further detail on these potential market failures and our assessment against each of the four elements is provided in the following paragraphs.

Figure 8.6 Summary of application of analytical framework to national DTT services

Identification of market failure argument	Problems with co-ordination result in DTT bidders not representing their true value in an auction	Capital market failures may prevent broadcasters from raising funds to purchase spectrum	Broader social values (BSV) generated from the use of the spectrum may not be factored into willingness to pay for spectrum	Advertiser-funded business model may result in producer value (and hence willingness to pay for spectrum) under-representing total value
Assessment of risk of market failure	Additional co-ordination is required, but leading DTT broadcasters have extensive experience of co-ordination	No evidence commercial DTT providers are prevented from accessing capital, but public sector broadcasters constrained by borrowing limits	BSV could exist, but likely to be relatively low for new services which are unlikely to include PSB content. Could be higher for PSB content in HD (considered separately)	Evidence is unclear, but there is some evidence to suggest that ad-funded model can extract sufficient consumer value of DTT. If it does not, this affects all scarce inputs, not just spectrum. Consumer value of additional DTT could be lower than research suggests, so significance could be limited. Pay-DTT provides alternative funding mechanism
Options for intervention and opportunity cost of spectrum	Option 1. Direct grant of spectrum - benefits and need uncertain, opportunity costs high because of amount of spectrum involved Option 2. Advantage DTT bidders in auction - benefits and need uncertain. Costs likely to be lower than option (1), but are uncertain Option 3. Financial and institutional framework to allow acquistion of spectrum if this is best use of resources available - benefits are directly related to delivery of public benefit; opportunity costs clear and transparent via award process			
Assessment of risk of regulatory failure	Option 1. Direct grant of spectrum - medium, could result in an excess supply of DTT if it over-compensates for market failures that are not certain Option 2. Advantage DTT bidders in auction - medium, still might not achieve appropriate amount of DTT and might not deliver broader social values			

	Option 3. Financial and institutional framework to allow acquistion of spectrum if this is the best use of resources available - low, regulatory intervention minimised could result in excess supply of DTT if it over-compensates for market failures that are not certain			
Conclusion	Do not intervene, but package spectrum in a way that enables potential DTT users to acquire spectrum	Do not intervene via spectrum, but package spectrum in a way that enables potential DTT users to acquire spectrum. Separate questions may arise about the ability of public sector PSBs to borrow	Do not intervene (HD case considered separately), but package spectrum in a way that enables potential DTT users to acquire spectrum	Do not intervene, but package spectrum in a way that enables potential DTT users to acquire spectrum

Figure 8.7 Summary of application of analytical framework to potential detrimental effects on DTT platform

Identification of market failure argument	Detrimental effects on the DTT platform may not be taken into account in DTT providers' willingness to pay for spectrum, specifically:			
	Detrimental effects on competition in digital TV market	Reduced efficiency in use of spectrum if viewers choose alternatives	Reduced ability of DTT platform to meet public policy goals	Weakened position of public service broadcasters
Assessment of risk of market failure	Evidence for diminution of competition uncertain. Not clear this is a failure of spectrum markets	Viewers switching platforms unlikely to result in net loss of efficiency	No evidence DTT platform would be less able to deliver PSB content universally	Effect uncertain; reducing competition to the PSBs on the DTT platform may result in viewers switching to alternative platforms to gain access to other services
Options for intervention and opportunity cost of spectrum	Option 1. Direct grant of spectrum - benefits and need uncertain, opportunity costs high because of amount of spectrum involved Option 2. Advantage DTT bidders in auction: benefits and need uncertain - costs likely to be lower than option (1), but are uncertain Option 3. Financial and institutional framework to allow acquistion of spectrum if this is best use of resources available: benefits - directly related to delivery of public benefit; costs - clear and transparent			
Assessment of risk of regulatory failure	Option 1. Direct grant of spectrum - medium, could result in an excess supply of DTT if it over-compensates for market failures that are uncertain Option 2. Advantage DTT bidders in auction - medium, still might not achieve appropriate amount of DTT and might not deliver broader social values Option 3. Financial and institutional framework to allow acquistion of spectrum if this is best use of resources available - low, regulatory intervention minimised could result in excess supply of DTT if it over-compensates for market failures that are not certain			
Conclusion	Do not intervene, but package spectrum in a way that enables potential DTT users to acquire spectrum			

Description of service

A8.323 Digital terrestrial television (DTT) is a service familiar to UK consumers already, and one which has achieved rapid growth in the last few years. The number of homes receiving digital terrestrial TV, on at least one TV in the house, has increased from around one million in late 2002, when Freeview launched, to 8.5 million homes by the end of June 2006 (including homes that have DTT on a secondary set as well as cable or satellite services on their main set). It is widely understood that DTT offers more channel choice than analogue terrestrial broadcasting, although less than cable or satellite services.

A8.324 The UHF spectrum made available by switchover is suitable for DTT broadcasting because it is within the frequency boundaries already used for other DTT signals. Household receivers and aerials are already designed to pick up and decode signals at these frequencies, albeit possibly with some retuning required.

A8.325 In the market research carried out on Ofcom's behalf in 2006, consumers tended to place a relatively high importance on increasing the number of channels on the DTT platform, both when considering themselves and society as a whole.

A8.326 An additional DTT multiplex carrying standard definition TV signals could offer eight, or possibly more, new channels to viewers in the area served by the multiplex. An additional national multiplex would probably require between one and tweleve of the fifteen cleared channels made available by switchover, depending on the coverage required and frequency planning. Additional DTT services would therefore require a significant proportion of the newly released spectrum.

A8.327 Currently, all publicly available digital terrestrial services are broadcast in standard definition. However, the public service broadcasters are trialling high definition DTT services in London and have expressed interest in launching HD services on DTT nationwide in future. The particular issues related to the potential delivery of HD services on the digital terrestrial platform are discussed in more detail in a separate section below.

A8.328 In the following sub-sections we first set out the potential market failure arguments which may be relevant to national DTT and then cover in turn the evidence which is relevant when considering these arguments, our assessment of the validity of the market failure arguments, the opportunity cost of intervention via spectrum, and finally, the potential remedies for these market-failure issues (including an assessment of their benefits and cost and regulatory failures). Finally, we set out our conclusion in relation to the potential market failure arguments.

Possible arguments for intervention

A8.329 If the released spectrum were awarded through a market-based process, broadcasters, transmission companies and/or other operators could bid for spectrum in which to deliver a new DTT multiplex or multiplexes. However our analysis has identified a number of factors that could in principle result in a market-based approach not leading to an efficient outcome. In other words, they might result in DTT providers not being able to reflect the total value to society of additional capacity in their bids for additional spectrum. It is important to assess whether it is possible that these factors could be sufficiently problematic to warrant

intervention in the award of spectrum. Each of the relevant factors is discussed in turn. These are:

- the challenges of **coordinating a bid for spectrum** may be more complex for DTT providers than for other potential bidders and hence may result in significant transaction costs;

- DTT providers' **access to capital** may be more constrained than other providers, for example owing to capital market imperfections, and therefore they may have difficulty raising funds to make investments in spectrum;

- the **DTT platform may be weakened** as a competitor to cable and satellite if it does not secure more capacity, resulting in detriment to consumers and citizens – a negative externality – that is not reflected in bidders' willingness to pay for spectrum;

- additional free-to-view DTT services may provide **broader social value** that would result in a positive externality that would not be reflected in revenues generated by advertising; and/or

- the use of **advertiser-funded business models** may result in free-to-view broadcasters being less able to extract the consumer value of their services to consumers than subscription service providers. If there is evidence to suggest this is the case, this structural difference between these funding models and those used for subscription services could result in free-to-view broadcasters being less able to afford additional capacity even if their services represent a high value use of the available spectrum.

A8.330 These arguments have been identified in a number of ways, but principally they have been put to us be potential users of the spectrum for DTT.

Problems of co-ordination

A8.331 A television multiplex broadcasts a number of channels which need not be, and generally are not, operated by a single broadcaster. It represents a means for a number of broadcasters to come together to broadcast channels in the most effective way.

A8.332 However, this means that individual broadcasters generally cannot bid directly for spectrum to meet their needs alone. Either they must develop partnerships with other broadcasters to jointly fund a bid for enough spectrum for a multiplex, or they must acquire the spectrum themselves and lease out any excess capacity to other broadcasters, or a third-party operator must acquire the spectrum and lease out multiplex capacity as an independent commercial venture. In the UK, the existing commercial multiplex operators are National Grid Wireless (NGW) and SDN, which is owned by ITV plc. They lease out capacity to a wide range of free-to-air broadcasters and to Top Up TV. The PSB multiplex operators are the BBC and Digital 3 & 4, jointly owned by the Channel 3 licensees and Channel 4.

A8.333 In all cases, additional co-ordination is required by operators of the DTT platform compared to vertically-integrated, single-ownership providers of other services that might take part in auctions for the available UHF spectrum. If this co-ordination were impractical, or heavily burdensome on DTT providers and broadcasters, they might be unable to put together a bid for capacity for an additional multiplex even if that were a high-value use of the spectrum. This is because the (transaction) costs

involved in co-ordination might deflate the willingess to pay spectrum relative to the private value generated by the use.

A8.334 Note that this argument could also apply to other potential users of the UHF spectrum that are not vertically integrated such as, for example, a PMSE band manager. Note also that this argument does not apply to all users of the spectrum for DTT: for example, it is plausible that some broadcasters may wish to carry only or mainly their own content on a multiplex.

Access to capital

A8.335 It might be argued that DTT providers could find it difficult to generate the capital required to compete in a market-based award process. By the nature of an auction process, DTT providers would be required to raise up-front funds to bid for spectrum that would only deliver revenues over a period of years, and might not generate any positive returns for the first few years. Consequently, it might be the case that DTT providers would struggle to raise the required funds from capital markets.

A8.336 This could apply equally to other potential services. Therefore, for this to result in a market failure in the award of the spectrum, DTT providers would need to be particularly likely to face constraints in capital markets which other providers (including providers of completely new services) might not face.

A8.337 Not-for-profit broadcasters face particular constraints as a result of their statutory funding arrangements. The BBC's funding is determined by a periodic licence fee settlement, and any need for additional funding to acquire spectrum could only be addressed as part of a review of that settlement. The licence fee settlement from 2007, which is likely to include the period of award of the available UHF spectrum, was in the process of being determined at the time of writing. The BBC is also subject to a borrowing limit set by the Government. Channel 4, although commercially funded, has a statutory limit of £200m on its borrowing, which could constrain its ability to bid for spectrum even if it expects to be able to service a debt higher than that limit, and to generate a significant surplus from that spectrum over the lifetime of its licence to use it.

A8.338 In principle these restrictions could result in these broadcasters not having ready access to the sums required to bid for spectrum even if they would represent the highest-value use to society of that spectrum.

Effects on the digital terrestrial platform

A8.339 The market for retail broadcast services and the delivery of these services in the UK, is characterised by rapid innovation and a constant search for new ways to deliver value to consumers. The ability of retail broadcast service providers using DTT capacity to compete with established cable and satellite providers, and with new entrants delivering IPTV services, may be constrained by available capacity on DTT multiplexes (which is restricted compared to these alternative delivery platforms). It could be that if DTT multiplex operators are unable to secure more capacity in future, retail broadcast service providers using DTT capacity could be adversely affected.

A8.340 The fact that the DTT platform is capacity constrained relative to other digital platforms is not of itself a market failure. If DTT is unable cost-effectively to compete with other platforms, taking into account its cost of capacity, then viewers

may well choose to switch to a platform that can offer a more compelling or cost-effective product. This is the normal working of a competitive market, not a failure in the allocation of capacity that requires intervention.

A8.341 For market failure to occur, it would need to be the case that DTT providers and operators were unable to take into account the effect of any potential weakening of the platform when assessing their willingness to pay for spectrum. This could in principle occur for two reasons:

- First it could be because of network externalities between those providers who already use the existing DTT capacity and those bidding for additional capacity. The former would benefit from the availability of additional capacity, if this helps to strengthen the DTT platform, even though they do not use this capacity themselves. However, this benefit may not be reflected in the amount other DTT providers are willing to pay for additional spectrum.

- Second, it could be that, because of the status of the DTT platform, other sources of external value, including broader social value, may be generated from strengthening the platform which are not fully reflected in the willingness to pay for additional capacity. This external value could be generated if for one or more reasons, there is value to consumers and citizens in ensuring the continued competitive strength of the DTT platform. If this value exists, and is not adequately taken into account in DTT providers' willingness to pay for spectrum, there may be a market failure, because the total value of maintaining the competitive position of the DTT platform would not be reflected in DTT providers' bids. Reasons why this external value might be present are set out in thefigure below and Ofcom's assessment of these arguments are set out below in Figure 8.8.

Figure 8.8 Description of effects of market failure arguments on the DTT platform

Argument	Description
Existing DTT spectrum: Bids for additional capacity will fail to take account of the reduction in the efficiency of the use of the existing DTT spectrum if viewers were to switch away from DTT because of lack of capacity	A large amount of spectrum is already set aside for DTT. The value to society, and therefore efficiency, of that use could decline if the DTT platform were less attractive and large numbers of viewers switched to cable and satellite services. Therefore the most efficient outcome for the use of the spectrum overall could be to maintain the attractiveness of the DTT platform by increasing its capacity, even if that is not the optimal use of the particular frequencies to be released at switchover
Competition: Bids for additional capacity will fail to take account of the detrimental impact upon competition in retail broadcasting services if the DTT platform becomes weaker because of lack of capacity	It could be argued that if the digital terrestrial platform becomes less competitive in future, leading more viewers to switch to cable and satellite, this would ultimately dilute competition in broadcasting services as a whole. If the dilution of competition were significant this could lead to weaker incentives to innovate, greater opportunities for uncompetitive practices by operators and worse outcomes for all consumers. Providing additional spectrum for the digital terrestrial platform might maintain or increase competition, leading to better outcomes for all consumers
Public policy goals: Bids for additional capacity will fail to take account of the impact of the DTT platform becoming weaker on the realisation of public policy goals such as	As a matter of public policy, there is a commitment to the digital terrestrial platform as the means of delivering near-universal availability of public service television (in standard definition). If the digital terrestrial platform is weakened to the point where its viability is uncertain, it is possible that its ability to meet this public service goal could be diminished

universal access to PSB content (in standard definition)	Additionally, it has been argued that there is an expectation held by UK society that the digital terrestrial platform will deliver an attractive service and that viewer expectations would not be met if additional capacity is not available, as this may result in it becoming a less attractive platform for broadcasters, leading to reduced quality and range of services available on the platform. Therefore as a matter of "public policy" it might be appropriate to maintain a strong DTT platform, by ensuring it has increased capacity after switchover
PSB funding: Bids for additional capacity will fail to take account of the impact of additional capacity on supporting the funding of public service television	The advertiser-funded public service broadcasters have a more significant presence on the digital terrestrial platform than on the cable and satellite platforms, because they represent a greater proportion of the channels broadcast on that platform. Increasing the capacity of the DTT platform would be likely to increase their market share and revenues, either indirectly (by making the DTT platform relatively more attractive, and therefore potentially taking customers from the cable and satellite platforms) or directly (if the PSBs acquire capacity to operate more channels in a new multiplex) By supporting the PSBs' competitive position in this way, giving additional capacity to the DTT platform could arguably help support their future ability to invest in public service content. It could also create the capacity for them to launch further public service channels, which might not be viable on strictly commercial terms if they had to bid for capacity but which could deliver significant benefits to citizens

Broader social values provided by broadcasting

A8.342 The next argument is that there may be broader social value arising from broadcast services which could be offered on additional capacity that would not be adequately captured either by the value attached by consumers to those services, or by the willingness of producers to fund those services. This issue is different to the potential broader social value issues discussed above, where the broader social value was generated from the relative strength of the DTT platform as a whole, rather from the particular use to which new capacity is put.

A8.343 To the extent that new DTT services might contribute to the purposes of public service programming – for example by informing ourselves and others, increasing our understanding of the world, stimulating interest in the arts, science, history and so on, and by making us aware of our own and others' cultural identity – they could create benefits to society that should be taken into account in assessing their total value to society, but that might not be recognised or taken into account by consumers or DTT providers.

A8.344 As a result it is argued that the bids made by DTT providers in a market-based award process may under-represent the potential broader social value of those services, and hence their total value to society. If there is disproportionate broader social value from the new DTT services compared to other services, the amount of spectrum DTT providers could be expected to win for the provision of such services could be less than it should be from the perspective of the optimal outcome for consumers and citizens. It could therefore be argued that there is a need for intervention to make up for this potential shortfall.

A8.345 It could be argued however, that this does not affect not-for-profit broadcasters such as the BBC and Channel 4, who have an incentive to take account of the broader social value their activities generate when deciding whether to launch new services. Therefore, subject to these broadcasters having sufficient resources to fund a spectrum purchase, there are no *a priori* reasons to believe that the amount they will bid will not be fully reflective of the total value to society generated.

Advertiser-funded business model

A8.346 Most companies that are likely to be interested in using the available UHF spectrum would charge their customers directly for the services they provide. Therefore, their willingness to pay for spectrum is likely to be fairly directly related to the value their customers attach to the services they deliver using that spectrum.

A8.347 However, it has been argued that the existence of different business models may mean that some service providers are less able to extract the value their customers derive from that service. Most advertiser-funded broadcasters have historically not charged viewers directly for receiving their services, because of the low marginal cost of delivering services to them and the difficulty of excluding viewers who have not paid. This includes all commercial broadcasters delivering free-to-view services on the digital terrestrial platform at present. In addition, the value to consumers provided by the BBC's services is not directly reflected in individuals' payments for BBC services, which are collected in the form of the compulsory licence fee. Therefore, it is possible that the revenues generated by these broadcasters will not reflect as high a proportion of the value consumers derive from watching programmes when compared to other (subscription based) services competing for the available UHF spectrum.

A8.348 If this is the case, it may be argued that the market may fail to achieve the optimal allocation of spectrum. As use of the advertiser-funded business model would result in DTT providers' willingness to pay for spectrum under-representing the total value to society of their output when compared to the willingess to pay for spectrum of providers of other services, such as those using subscription-based business models.

A8.349 The following section discusses the evidence for and against these arguments that was collected in the DDR.

Evidence gathered by the DDR

Technical analysis

A8.350 In November 2006, DTT viewers could receive up to 32 national predominately free-to-air TV services, depending upon where they live and how many of the existing six multiplexes they receive, with pay-TV services available to Top Up TV subscribers. By the time of switchover, we anticipate the adoption of a more efficient transmission mode on some of the existing multiplexes, and the better use of existing capacity, could increase the number of TV services available on the current six multiplexes to up to 49 (using the MPEG2 compression standard).

A8.351 One or more additional DTT multiplexes could be provided using the cleared channels released by digital switchover. In addition, an additional multiplex could be created in interleaved frequencies. However, the coverage and availability of any new multiplex will vary depending on which, and how much, spectrum it uses.

A8.352 For example, our analysis suggests that a multiplex covering at least 95% of homes could use six channels, either all in the lower part of the released spectrum band (channels 31-35, 37, 39, 40), or in the upper part (channels 63-68), or in a mixture of both (channels 31-33 and 63-65). It would be possible to deploy a multiplex with fewer than 6 channels but this would result in a lower level of coverage, possibly as low as 60% if only 3 channels were used.

A8.353 However, many household aerials do not cover the entire frequency range covered by the available UHF spectrum, instead they are only capable of receiving signals within one part of the band. It is possible, therefore, that depending on which frequencies are used, and whether they are contained within one part of the band or spread across all of it, that some households would have to upgrade to new 'wideband' aerials capable of receiving signals across the entire band if new DTT services, that those households wanted to watch, were broadcast at frequencies not 'in-group' for their existing aerials.

A8.354 In the three scenarios described above – lower band, upper band or mixed band – a six-channel multiplex would not be adequate to provide in-group frequencies for all locations. In the lower band scenario, the new DTT channels would be likely to be out-of-group for households at 30 transmitter locations, including Manchester, Oxford and Bristol. In the upper band scenario, services would be out-of-group for 53 locations, including London, Birmingham, Glasgow and Southampton. The mixed band scenario reduces the problem, but even then the new services would be out of group in 17 locations, including Birmingham & Glasgow.

A8.355 Using frequencies across the band that are in-group at all transmitter locations is possible, but very spectrum-hungry. Our technical analysis suggests that in most locations, additional in-group frequencies could be found for a new DTT multiplex, thereby removing the need for viewers to replace their aerials; however this would require 12 of the 15 cleared channels to be dedicated to the new multiplex (although this would leave sufficient interleaved capacity within these 12 channels for other compatible uses, including a second additional DTT multiplex).

Market research

A8.356 Market research carried out for the DDR suggests that the perceived importance associated with DTT services from an individual consumer point of view is relatively high. In our quantitative research, additional DTT services were the potential use of the available UHF spectrum that consumers were most interested in, followed by mobile broadband and mobile TV.

A8.357 However, this greater interest in DTT services was not reflected in stated willingness to pay, with viewers willing to spend roughly the same – a relatively small amount – for each of the services tested including those which were rated as less important. Most consumers were not prepared to pay more than £5 per month, perhaps reflecting the fact that most DTT services are provided free-to-view at present.

A8.358 With respect to broader social value, the available evidence suggests that DTT as a whole offers some broader social value in addition to private consumer value. This was the conclusion of Ofcom's first PSB Review and it is supported by the bottom-up analysis carried out for this study.

A8.359 However, our research and analysis suggests that the incremental broader social value offered by additional DTT could be relatively small, in the region of up to 10%

of the private producer and consumer value of additional DTT channels. The size of this additional broader social value depends largely on the content of the specific services provided, therefore, if additional public service channels were offered it is possible that the extra broader social value could be greater than this. However, in the case of additional standard definition channels, stakeholders have not signalled any desire to launch further public service channels, and it is likely that any additional capacity would either be used to launch commercial services or for high definition PSB services (see section on HD).

A8.360 It is also important to recognise that other services are likely to have incremental broader social value. This includes other potential uses of the available UHF spectrum and may also include other television platforms.

Stakeholder engagement

A8.361 Stakeholders have informed us that the PSB broadcasters are strongly in favour of intervention to secure additional capacity for the DTT platform. However, many were sceptical about the value of additional SDTV services on DTT. They were most interested in use of additional capacity for high definition services, which is discussed in more detail below.

A8.362 The appears to be limited interest from stakeholders to deploy either pay or free-to-view multiplexes carrying additional SD channels. The public service broadcasters have made no indication that they would be interested in using additional spectrum to providing more channels with a formal public service remit.

Demand analysis

A8.363 Many of the arguments for intervention to ensure additional capacity for DTT services hinge on the claim that the digital terrestrial platform would be less able to compete with other TV platforms, and its viewers would switch to other platforms, if it does not secure additional capacity after switchover.

A8.364 At present, there is little evidence to confirm or deny this risk. On the one hand, DTT already has significantly less capacity than cable or satellite platforms, and less capability to deliver enhanced services such as on-demand and pay-per-view content. Nonetheless the story of digital TV take-up in the last few years is one of dramatic growth in the digital terrestrial platform as growth slows in take-up of cable and satellite services. This suggests at a minimum that the DTT platform's ability to compete has not been principally driven by the capacity of the platform.

A8.365 On the other hand, it is at least possible that in future the relative lack of capacity on the DTT platform could render it less able to compete as effectively, especially if it does not have the technical means to deliver the kind of enhanced services now beginning to appear on the cable and satellite platforms. If services such as Sky+, high definition or on-demand content stimulate increased growth in cable and satellite take-up, and increased switching from analogue terrestrial or digital terrestrial TV to pay platforms, this might weaken the competitive position of the DTT platform.

A8.366 It is impossible to be certain about future dynamics in such a rapidly changing market, except to note that there does not seem to be any compelling evidence of constraints on DTT's ability to compete at present. However, it is important to note that the DTT platform will remain relatively constrained, in terms of capacity and technical capability, compared to satellite and cable platforms. However, even if all

the available UHF spectrum were allocated to DTT, this would only increase the capacity of the platform by around one third; cable and satellite platforms already have many times greater capacity than this. It seems likely that if lack of capacity is a constraint on DTT's ability to compete, this would only be partially mitigated even if all the available UHF spectrum were allocated to DTT.

A8.367 One argument suggests that the public service broadcasters could have particular problems raising the funding for spectrum bids in capital markets. However, there is no compelling evidence of any capital market failing in relation to advertiser-funded broadcasting, which is a well-established business model; the UK has one of the most developed capital markets in the world, and the major companies in the sector appear to have faced significant difficulties acquiring investment funding in the past.

A8.368 The situation is rather different for public sector broadcasters, which are subject to regulatory constraints on borrowing, via Government controls. However, absent these controls, they would be likely to enjoy easy access to capital markets because of the implicit guarantee represented by public ownership and, in the case of the BBC, the security of its funding through the licence fee.

Economic modelling

A8.369 Modelling suggests that it is difficult to assess whether there is any unusually large differential between DTT providers' willingness to pay for spectrum and the value attached by consumers to new free-to-view services when compared to the ratio of these values exhibited by other potential uses of the available UHF spectrum.

A8.370 If the value viewers attach to additional channels is very high, the ratio between willingness to pay for spectrum of free-to-view broadcasters and consumer value could be relatively low. However, if the value viewers attached to additional channels is relatively low, then our modelling suggests that this ratio is not significantly different to that which we expect for other potential uses of the spectrum.

A8.371 There is significant uncertainty over the value consumers will derive from additional channels on the DTT platform as this will depend upon how the DTT platform might evolve over the next few years as additional capacity becomes available at switch-over and as contracts for access to multiplex capacity come up for renewal. The experience of recent channel launches on the DTT platform shows that it is possible to achieve a relatively high audience share compared to other digital-only channels – but the audiences of these channels remain very small compared to the main five channels. The audience share of ITV2 for example, one of the most successful digital-only channels, was only 2.2% in multi-channel homes in 2005. This might lead us to think that the incremental value of those channels to DTT viewers is relatively small compared to the value of the main five channels. However, even if the audience share of additional channels is low, the total audience share of a new multiplex may not be insignificant.

A8.372 Our qualitative research suggests that the perceived value to society viewers attach to new channels depends heavily on what the content of those channels is. It is reasonable to assume that, the private value viewers would attach to channels showing new or highly attractive content – for example sports and movies – could be relatively high. The value they would attach to channels showing similar content to what is already available is likely to be significantly lower. Therefore, if additional content offered via advertiser funded broadcasters is mass-market in its appeal, rather than premium or niche content (which is more commonly offered on a pay

basis), it does not seem unreasonable to assume that the value of these incremental channels to consumers could be relatively low.

Assessment of the case for intervention

A8.373 The following paragraphs assess each of the possible arguments for intervention outlined above, based on the evidence collected in the DDR. This analysis seeks to establish whether there is reason to believe that the factors identified would, in fact, mean that a market-based approach to the award of the available UHF spectrum would be likely to result in a suboptimal outcome for society.

A8.374 This section does not attempt to assess the benefits and costs of any potential remedies; nor does it discuss whether these remedies would be an appropriate solution to any problems identified. These issues are covered in a separate section.

Problems of co-ordination

A8.375 It is likely that additional co-ordination will be required by DTT providers compared to some other potential bidders for the spectrum. The question is whether this co-ordination is impractical or particularly costly. The public service broadcasters already cooperate between themselves and with other broadcasters on a range of areas, including transmission arrangements, marketing of DTT services through Freeview, collection of audience viewing data through BARB and so on. This would suggest that they would be well placed to work together in order to mount spectrum bids; in the case of Channel 3 and Channel 4, a vehicle for this cooperation already exists in the form of Digital 3 & 4.

A8.376 Furthermore, at the multiplex level, there are already two companies with experience of setting up, operating and leasing out capacity on DTT multiplexes – NGW and SDN – in addition to the PSB multiplex operators. Either or both these companies or other companies may seek to raise funds to mount bids for spectrum, which could then be leased out on a commercial basis in exactly the same way that capacity on the existing multiplexes is. The costs of mounting a bid seem unlikely to represent an insurmountable obstacle, assuming that the potential bidder has access to sufficient investment to fund the bid itself (see discussion of this issue below).

A8.377 For these reasons we believe that there is no strong evidence to suggest that co-ordination places an excessive or impractical burden on DTT providers.

Access to capital

A8.378 The sums required by DTT providers to make up-front bids for spectrum may represent fairly significant investment decisions. But for commercial broadcasters, or for commercial multiplex operators, it is unclear why they should have any particular difficulties raising funds for this kind of investment. If DTT providers can make a compelling business case for investment in additional capacity, we have seen no evidence to suggest that they would have undue difficulties acquiring funding to deliver it.

A8.379 However, there may be a problem arising from constraints on the public sector broadcasters' ability to borrow to fund investments that might deliver commercial returns in future (for Channel 4) or significant broader social value (for the BBC and Channel 4). The question is whether it would be more appropriate to intervene in spectrum markets to directly provide the broadcasters with the inputs they need, or

to adjust constraints on their borrowing to enable them to raise funds to acquire those inputs in the open market. This is a question that applies not just to access to spectrum, but potentially to any resource.

A8.380 We return to this question below, but note that it is unclear whether the not-for-profit broadcasters do lack the financial resources to fund a spectrum bid. In its current Charter, the BBC has a public service borrowing limit of £200m, and can draw on this and any cash balances to fund investments and year-to-year operating deficits, subject to its long-term commitment to return to 'broadly zero' debt by the end of the Charter. At 31 March 2006 it had cash at bank and in hand of £160.2m. Channel 4 currently also has both substantial reserves and the capacity to borrow up to £200m to fund new investments. It may be that both broadcasters could accommodate the costs of additional spectrum within their existing financial regimes, depending on the willingness to pay for spectrum of other possible users.

Effects on the digital terrestrial platform

A8.381 There are a number of potential reasons that have been advanced for intervention to support the DTT platform after switchover. Our assessment of the detailed arguments is set out in thefigure below.

A8.382 Before assessing these issues, it is worth considering why DTT providers and operators might not be able to factor in the effect of additional capacity on the DTT platform in their willingness to pay for additional spectrum.

A8.383 Where the effect of the strength of the platform on producer and consumer value is concerned, it is unclear why providers on the DTT platform would not take into account the potential effect of additional capacity. If viewers were to switch away from the DTT platform because of lack of capacity, this would have a detrimental impact upon all DTT broadcasters and the DTT multiplex operators. While there is the potential for a network externality to occur between broadcasters who use existing capacity (and hence who benefit from additional capacity even if they do not bid for it or use it) and those parties who would bid for additional capacity, there are a number of reasons why we would expect this network effect to be internalised within the bids made.

- There is a relatively small number of broadcasters that account for the majority of the viewer hours broadcast on the DTT platform;
- There is a small number of DTT multiplex operators; and
- These parties already have experience of co-ordinating their activities on the Freeview service.

Therefore, if it is in their joint interest to bid for additional spectrum in order to prevent the DTT platform becoming a weaker competitor relative to other platforms, there do not appear to be strong arguments to suggest that these would not be factored into a bid for additional spectrum for this use.

A8.384 Difficulties may emerge however, if the relative weakness of the DTT platform generates external benefits or costs which impact upon producers or consumers who do not use the DTT platform. Four arguments for the presence of this form of external effect are discussed below.

Figure 8.9 Assessment of effects of market failure arguments on the DTT platform

Argument	Assessment
Existing DTT spectrum: Bids for additional capacity will fail to take account of the reduction in the efficiency of the use of the existing DTT spectrum if viewers were to switch away from DTT because of lack of capacity	If the DTT platform loses viewers, it may represent a less efficient use of resources; but other platforms, which have gained viewers, will be using their resources more efficiently. There is no net loss of efficiency for society as a whole However, it could be argued that this does not take into account the value lost by those viewers on the DTT platform who would not switch to other platforms even if the DTT platform does not acquire additional capacity. It is reasonable to assume that if the DTT platform becomes less competitive, some channels will leave the platform, reducing the value provided to those viewers who remain. However, the majority of viewing on the DTT platform is to the channels operated by the public service broadcasters, which would presumably remain on the DTT platform even if its market share declines, suggesting that the impact on remaining DTT viewers of any loss of market share is likely to be small
Competition: Bids for additional capacity will fail to take account of the detrimental impact upon competition in retail broadcasting services if the DTT platform becomes weaker because of lack of capacity	If the DTT platform were to be weakened to such an extent that it offered less competition to cable and satellite platforms it is not clear how significant a lessening of competition in provision of broadcaster services in the UK would result, nor that subsidising the platform by awarding it additional capacity would be the most appropriate solution to the problem. Competition law and sector specific regulation creates a range of mechanisms for assessing and addressing weak competition. Competitor subsidies is not a solution that would usually be considered
Public policy goals: Bids for additional capacity will fail to take account of the impact of the DTT platform becoming weaker without additional capacity on the realisation of public policy goals such as universal access to PSB content (in SD)	The public policy commitment is to ensuring near-universal availability of the public service channels, using the digital terrestrial platform as the means of delivering this. This commitment is reflected in the 2003 Communications Act, in licences issued by Ofcom to Channel 3, 4 and 5 licensees and in regulation of the BBC by the Government This commitment is not threatened by any risk that the DTT platform might become less attractive and competitive in future, since the public service channels will always be available on the platform as long as this policy commitment persists There is no broader policy commitment to particular content or service offerings on the DTT platform. There is a commitment to achieving digital switchover, but this is a platform-neutral policy which does not favour any particular platform over another It might be argued that consumers have come to expect a high quality offering on the DTT platform, particularly in the context of switchover, and will suffer if the platform's ability to keep up with cable and satellite is compromised after switchover. This argument might particularly apply if the DTT platform is unable to offer some of the enhanced services now in development on other platforms, such as high definition TV. We return to this issue below
PSB funding: Bids for additional capacity will fail to take account of the impact of additional capacity on	The PSBs command a higher market share on the DTT platform, and (within the terms of any regulation) they could use additional capacity to maintain their competitive position against the cable and satellite broadcasters, or to develop additional channels generating

supporting the funding of public service television.	commercial returns that they could reinvest in their core PSB services In general, Ofcom's PSB Review suggested that the strategy of supporting PSB by limiting competition, was unlikely to be effective in future, or in viewers best interests. This strategy may shore up market share of the DTT platform, but may also encourage viewers to switch to other technologies – on-demand services, video downloads, DVDs or mobile services – to access the content they want to watch, if it is not available on their main digital TV service. It is highly unlikely to be in the interests of citizens and consumers to intervene to suppress competition in this way. We return to this in the discussion of possible remedies below

A8.385 Therefore, the assessment of the arguments set out above suggests that there do not seem to be strong reasons to believe that the availability of additional capacity for the DTT platform will result in external values which should be reflected in a bid for spectrum but which will not be factored into the willingness to pay for spectrum of DTT providers and operators. Hence, there do not appear to be strong reasons to suggest that a market failure would occur for this reason.

Broader social values provided by broadcasting

A8.386 With respect to broader social value, our research suggests that additional DTT capacity could provide some additional value to society, although it is unlikely to be a large supplement to private value. Again, the level of broader social value provided by additional DTT services depends heavily on their content. It seems likely that any new services launched on the DTT platform would be commercial in emphasis, rather than public service – the public service broadcasters have made no indication that they would be interested in providing more channels with a formal public service remit, and in fact the BBC has ruled out launching any more channels. Therefore there is little evidence to suggest that the incremental broader social value, over and above what is already generated by the existing public service channels, provided by additional DTT services would be disproprtionately large compared to other services competing for the available UHF spectrum.

Advertiser-funded business model

A8.387 This argument rests on the assertion that free-to-view broadcasting will be less able to reflect the consumer value which it generates than subscription based services because of the indirect nature of the link between advertising revenues and consumer value, and that the impact of this will be that free-to-view broadcasters will be unable to reflect the value to society they generate on a comparable basis to other potential bids for the available UHF spectrum.

A8.388 For many broadcasters the choice of funding model, free-to-view versus subscription, is a choice they make in response to their commerical incentives. Therefore, the use of a free-to-view funding model should not be assumed to be given. It is also worth keeping in mind that the relative consumer value of a free-to-view versus subscription model is unclear. Consumers benefit from a free-to-view model as this reduces exclusion (as all consumers can access the content for free) but consumers also benefit from subscription services as these can better reflect the value they derive from the content provided (as advertiser funding results in broadcasters providing content to target either mass audiences or viewers from demographics which are valuable to advertisers).

A8.389 However, our assessment is that the presence of this risk of market failure would not always result in a market failure and even if it did, the appropriate response to this issue is not clear:

- The use of a free-to-view model is in itself a remedy to another market failure, namely the public good characteristics of broadcasting.
- This market failure will not be limited to the market for spectrum. If it is a problem it will be an issue for all inputs for which a free-to-view broadcaster competes against a subscription-based service[35].
- As mentioned above, there is uncertainty over whether free-to-view broadcasting maximises the consumer and citizen value which can be generated from broadcasting.

A8.390 The argument for this market failure relies on two assumptions: that compared to other potential uses of the spectrum there is a less direct relationship between the value consumers and citizens would attach to new free-to-view TV services on the DTT platform and DTT providers' willingness to pay for spectrum to deliver those services, and that the free-to-view model is the only viable way to deliver that value. Based upon our modelling work the first assumption may hold when the consumer value generated by the content offered is high. However, when this is the case, the assumption that a pay service is unviable is least likely to hold.

A8.391 Therefore there is uncertainty over whether in general there is any mis-match between the value consumers attach to free-to-view broadcasting and DTT providers' ability to extract that value. There does not appear to be compelling evidence that free-to-view broadcasting suffers from a major problem of under-provision, which might have suggested an inability to extract value from this business model – the rapid growth of Freeview over the last few years demonstrates that the free-to-view model is still very much alive. The transition of channels like E4 and FilmFour from subscription services to free-to-view, and the launch of channels like Sky Three and abc1 on the digital terrestrial platform, suggest that, if anything, some broadcasters feel they can extract more value from a free-to-view model on DTT, rather than less.

A8.392 Nonetheless, there is evidence from our research to suggest that there is a potentially large value attached by consumers to new free-to-view services. But our research also suggested that the value viewers attach to new channels depends heavily on the content of those channels.

A8.393 It is uncertain that an expansion of capacity on the DTT platform would result in significantly more attractive content being broadcast than what is already available. In theory, the most attractive content would be likely to be already provided on the platform or will be provided in the future as channels that are more highly valued by viewers become available, as these will displace lower value channels as contracts for multiplex capacity come up for renewal. It is theoretically possible that more niche services, of limited mass appeal but of very high value to a minority of viewers, could be provided in additional capacity; but in fact advertiser funding creates an incentive to provide content that is insufficiently differentiated because of

[35] However, this is only likely to have a significant impact when the availability of inputs have an impact on the ability to provide the service or upon the quality of service which can be provided. Therefore, the relevance of the market failure risk is likely to be tied in part to the lumpiness of the resource under consideration.

the need to attract either a mass audience or viewers from demographics which are highly valued by advertisers. This suggests that the incremental value to consumers of new free-to-view services could be significantly lower than viewer research suggests.

A8.394 Moreover, if broadcasters were able to use new capacity to provide significantly more valuable content than is already available on the DTT platform, it is not clear why they would choose a free-to-view model to do so. Pay-TV services on DTT are already available via Top Up TV; Setanta has announced that it intends to provide access to its Premiership football on a pay-per-view basis from 2007, and by 2012 the provision of pay services via the DTT platform could be more established than is currently the case. If broadcasters are unable to extract the value to consumers of highly attractive content using a free-to-view model it is reasonable to assume that they might explore a pay-TV route instead – which would remove the potential problems associated with a free-to-view funding model. Pay-TV models on the DTT platform have not been as successful to date as the free-to-view model, perhaps because generally they have not had access to content as attractive as that provided by satellite and cable services – which in turn casts doubt on whether the incremental value to consumers of new DTT services would really be large enough to suggest market failure.

A8.395 Additionally, the magnitude of the impact of any such mis-match will depend upon the lumpiness of the spectrum resource. For DTT there is considerable flexibility over the amount of spectrum required to provide a service (for example a 60% coverage mux could be provided using three 8MHz channels and increasing the number of channels used to 6 could increase the coverage achieved from 60% to around 95%). Therefore, to the extent that the market failure occurs its impact may be to reduce the amount of spectrum which DTT acquires, and hence the coverage of additional free-to-view services, rather than to preclude this use entirely.

A8.396 Therefore, we consider there to be insufficient evidence to suggest that this market failure would occur or, that it would have enough of an effect in relation to the award of the UHF spectrum to justify intervention.

Overall assessment of the case for intervention

A8.397 Overall, we conclude that many of the arguments for intervention to ensure additional capacity for standard definition DTT are not sufficiently compelling. It is unclear that the consumer value generated by more free-to-view television could not be captured by broadcasters and reflected in DTT providers' bids for spectrum (to a similar extent as other services), nor that commercial operators would have disproportionate difficulty raising the funds for bids in capital markets. And, if the DTT platform did not manage to secure additional capacity in a spectrum auction, it is not clear that this would result in any undue consumer or citizen detriment, or in the breaking of any public policy commitments.

A8.398 One question which is worth further consideration is whether the not-for-profit broadcasters, the BBC and Channel 4, are unduly constrained in their ability to bid for spectrum by limits on their borrowing capacity.

A8.399 Finally, the potential provision of high definition services on the DTT platform, may raise questions of both private consumer value and broader social value. This is addressed in more detail in the section on the transition to HD on the DTT platfrom below.

Opportunity cost of spectrum intervention

A8.400 If spectrum were to be used as a means of intervening to resolve a market failure, the opportunity costs of doing so for DTT are relatively high. In principle a 60-70% coverage multiplex could be achieved using one 8MHz channel but would require access to channel 36. Alternatively an additional multiplex provided using three to five channels in the cleared spectrum could achieve coverage of between 60% and 95%. However, both of these options would not achieve ‘’universal’’ coverage and would not be in-group for many existing household aerials. To achieve 98.5% coverage of services at frequencies in-group for almost all households’ aerials may be possible with as few as six channels but could require upto 12 channels, spread across both the upper and lower bands of the cleared spectrum. In this case, DTT could account for the majority of the spectrum released by switchover, precluding a wide range of alternative uses and incurring a very high opportunity cost.

Potential remedies, benefits and costs

A8.401 We have concluded that the case for intervening to deliver more capacity for standard definition TV is uncertain hence that there is insufficient evidence to justify intervention. But even if there were a case for seeking to ensure that the broadcasters were able to secure additional capacity for standard definition TV after switchover, we suggest it is unlikely that directly awarding them the spectrum would be the most appropriate way of achieving the objective.

A8.402 Most of the arguments in favour of intervention for DTT are of the following form: there are benefits to citizens and/or consumers of creating more capacity on the DTT platform, but for one or more reasons DTT providers, and the public service broadcasters in particular, are unlikely to be able to afford to fund the bids required to win the spectrum.

A8.403 We have argued that the benefits are not certain; and to the extent that they do turn out to exist, it is unclear that DTT providers will not be able to raise the funds to secure them, with the possible exception of the public sector broadcasters who have constraints on their borrowing capacity. But if the benefits do exist and DTT providers are unable to raise the required funds, there are a number of possible solutions to this problem.

A8.404 First, Ofcom could award the spectrum directly to DTT providers, or auction part of the spectrum under terms that restrict its use to provision of DTT capacity. This would ensure that additional DTT capacity is available after switchover. However it would greatly reduce the flexibility of use of the spectrum, and given the opportunity cost of this type of intervention, it would risk significant regulatory failures if our assessment of the benefits of additional DTT turned out to be incorrect. Moreover, by awarding the spectrum in this way, we would reduce the incentives on users to ensure spectrum is used as efficiently as possible for society.

A8.405 Second, Ofcom could hold an open auction, but confer an advantage on DTT providers to reflect the additional benefits that use of the spectrum for DTT could deliver, but which could not be internalised in DTT providers’ bids. This could include giving DTT providers bidder credits, or packaging the spectrum in a way most compatible with its use by DTT, or imposing constraints on the use of the spectrum.

A8.406 This could help ensure that sources of value associated with DTT, but not taken into account by commercial providers, are represented and taken into account in

the award process, without closing down possible alternative uses of the spectrum entirely. However it would be difficult to assess exactly what level and type of intervention would achieve the desired effect, which means that the risks of regulatory failure are again significant. Moreover, by awarding spectrum in this way, we would distort the incentives of the preferred users in relation to the use of spectrum versus other inputs.

A8.407 Third, Ofcom could auction the spectrum on a technology and use neutral basis, but suitable adjustment could be made to the financial and institutional framework for organisations delivering public services to allow the acquisition of spectrum if this is the best use of their resources in pursuit of public sector objectives. This approach would be most likely to lead to the most effective use of spectrum for the benefit of society (both at the time of the award and in the future), and would ensure transparency in the funding of PSB. It is discussed in more detail in the HD section of this annex. It would also (subject to details of the framework) ensure incentives for the efficient use of resources.

Ofcom's proposal

A8.408 We have not seen sufficient evidence that use of the spectrum for additional standard definition DTT services would deliver value to society that could not be adequately reflected by DTT providers in their bids for spectrum, nor that if such value did exist, intervention in the award process would be the best way of delivering it.

A8.409 Therefore we propose to make no intervention in the award process for the available UHF spectrum to support its use for additional free-to-view DTT services. However we propose to package the cleared spectrum so that it enables DTT users to acquire spectrum. In addition, we are fully committed to understanding potential sources of value to society that could be provided using the available UHF spectrum, and to helping to ensure that the right frameworks are in place to enable value to society to be delivered under the market-based approach to this spectrum award.

High definition on DTT

Summary

A8.410 Set out below is a summary of the result of our assessment against each of the four elements which need to be considered to allow an assessment of whether intervention is justified to resolve a risk of market failure (as set out in Annex 7 above).

A8.411 Further detail on these potential market failures and our assessment against each of the four elements is provided in the following paragraphs.

Figure 8.10 Summary of application of analytical framework to HD on DTT

Identification of market failure argument	If other platforms move to HD in future, there may be a negative external value impact on consumers and citizens because of the impact of this on the attractiveness of the DTT platfrorm if sufficient capacity is not available on the DTT platform to enable both HD and SD services to be broadcast. This impact on consumers and broader social value will not be factored into the DTT providers' and operators' willingness to pay for spectrum	If the availability of PSB content in HD becomes important for the realisation of broader social values from universal availability of PSB content, the impact of the availability of additional capacity on the ability to realise this value to society may not be adequately reflected in DTT providers' and operators' willingess to pay for spectrum
Assessment of risk of market failure	Widespread or complete transition to HD is possible, although uncertain. If this transition does take place there is a range of strategies PSBs could use to deliver the main five channels in HD, including on the existing multiplexes, deploying Freesat, using cable and satellite networks, developing IPTV services and acquiring more DTT capacity. Therefore benefits of providing more DTT capacity for HD in the available UHF spectrum may be relatively limited	The occurrence of this market failure depends on a number of assumptions, all of which are uncertain. These include the universal requirement for PSB content in HD, the need to realise this objective via the DTT platform and the need for additional spectrum to allow the DTT platform to achieve this. It is also unclear whether or not DTT providers and operators would be able to factor this effect into their bid for additional spectrum
Options for intervention and opportunity cost of spectrum	Option 1. Direct grant of spectrum - likely to be high opportunity cost Option 2. Advantage DTT bidders in an auction - opportunity cost could be high depending on scale of intervention Option 3. Financial and institutional framework to allow acquistion of spectrum if this is best use of resources available - opportunity costs expressed through transparent process for releasing spectrum	
Assessment of risk of regulatory failure	Option 1. Direct grant of spectrum - high, given uncertainty about future development of HD Option 2. Advantage DTT bidders in an auction - high, given uncertainty about future development of HD Option 3. Financial and institutional framework to allow acquistion of spectrum if this is best use of resources available - low, reguatory intervention minimised could result in excess supply of DTT if it over-compensates for market failures that are not certain	
Conclusion	Do not intervene, but package spectrum in a way that enables potential DTT users to acquire spectrum	

Description of service

A8.412 High definition television (HDTV) has recently launched in the UK, carried on satellite and cable. In addition, the national public service broadcasters launched a restricted technical trial of terrestrial HDTV in London in June 2006.

A8.413 HDTV offers higher-resolution images which have sharper image detail and it is claimed offer a richer, more involving viewer experience. At present, most HDTV-compatible sets have relatively large screens, starting at around 28". Manufacturers are beginning to develop HDTV-compatible sets with smaller screens, although it is likely that the improvements in picture quality will be less apparent on smaller screens.

A8.414 As with standard definition TV, the available UHF spectrum is well suited to HDTV broadcasting partly because households already have aerials capable of receiving the frequencies that would be used.

A8.415 A new national multiplex carrying HDTV would use the same bandwidth as a standard definition multiplex – that between 1-3 and 12 channels, depending on frequency planning and desired coverage. However HDTV is very bandwidth-hungry, and as a result it is currently forecast that such a multiplex would only provide capacity for up to three high definition programming channels[36].

A8.416 HDTV is a relatively new enhancement to television services in the UK and it is not yet clear how consumer demand will develop. HDTV might remain a minority interest, purchased at a premium by consumers with particular interests (for example in sports content) or who attach particular value to improved picture quality. Alternatively, HDTV-ready receivers might become the norm as households replace their existing TVs with new sets, leading to an expectation that certain services, for example PSB channels and certain subscription channels such as sports, movies and wildlife channels, would be universally available in this mode.

A8.417 However, for as long as a significant number of households do not have HD-compatible equipment, it might be necessary to simulcast at least some channels – including the five main public service channels – in high and standard definition. It is unlikely, therefore, that introducing HD on the DTT platform would increase choice of content for viewers with HD equipment – rather the benefits would be felt initially as enhanced viewing quality for those viewers.

A8.418 In the following sub-sections we first of all set out the potential market failure arguments which may be relevant to HD on DTT and then cover in turn the evidence which is relevant when considering these arguments, our assessment of the validity of the market failure arguments, the opportunity cost of intervention via spectrum, and finally, the potential remedies for these market-failure issues (including an assessment of their benefits and costs and potential regulatory failures). Finally, we set out our conclusion in relation to the potential market failure arguments.

Possible arguments for intervention

A8.419 There are two arguments for intervention in relation to HD on DTT. The first argument relates to the effect which the availability of HD content has upon the DTT platform (and any resulting impact of this on consumers and citizens if the DTT

[36] Using MPEG4 compression technology.

platform becomes weaker compared to alternative broadcasting platforms). The second argument relates to the impact of additional capacity on the realisation of universal access to PSB content in HD.

A8.420 In either case, the market failure arguments rest upon the impact of additional capacity upon the ability of the DTT platform to offer HD not being adequately reflected in a bid for additional spectrum because of the presence of external value considerations and the inability of potential bidders for spectrum to reflect that value in their bids. The first argument relates to external value caused if the relative weakness of the DTT platform effects other consumers (ie viewers of the DTT and other platforms), other producers (ie operators who are not bidding for additional spectrum), and/or citizens. The second argument relates to the broader social value which could be generated from the universal availability of PSB content in HD in the future.

A8.421 The reasons why external value could be present in these cases are the same as those covered in the arguments which have been discussed in the section above under the headings of “effects on the digital terrestrial platform” and the “broader social values provided by broadcasting”. In this section we focus on whether our assessment of those arguments may be different in relation to the provision of HD.

A8.422 We do not reconsider the other market failure arguments discussed in the section above here, as we do not consider there to be compelling reasons why the arguments (for co-ordination or advertiser funding market failures) would apply differentially for the availability of HD content on the DTT platform compared to SD.

A8.423 We now consider in what circumstances might the emergence of HD broadcasting change our assessment of the potential for external value market failures in the market for spectrum. We firstly consider general factors which apply to both of the potential market failure argments and then consider additional factors which are relevant to the argument about the availability of PSB content in HD.

A8.424 The general factors which apply to both of the potential market failure arguments are as follows. If HDTV becomes widespread, and is highly valued by consumers and citizens, it is possible that it could become the de facto standard format of broadcasting. If, for example, the cable and satellite platforms deliver most or all channels in HD, many viewers might come to expect and require the higher quality pictures and sound associated with this standard of broadcasting, and no longer be prepared to watch any remaining standard definition services. In particular, they might not accept a DTT platform that could only deliver standard definition.

A8.425 If this scenario developed, the DTT platform would probably also need to make a similar transition to HD. If it did not, commercial channels might shun the platform, preferring only to produce in high definition, and large numbers of viewers might switch to other platforms, aggravating the weakening effects on the DTT platform discussed in the previous section. In extremis, the DTT platform could cease to be an alternative to cable, satellite and IPTV services.

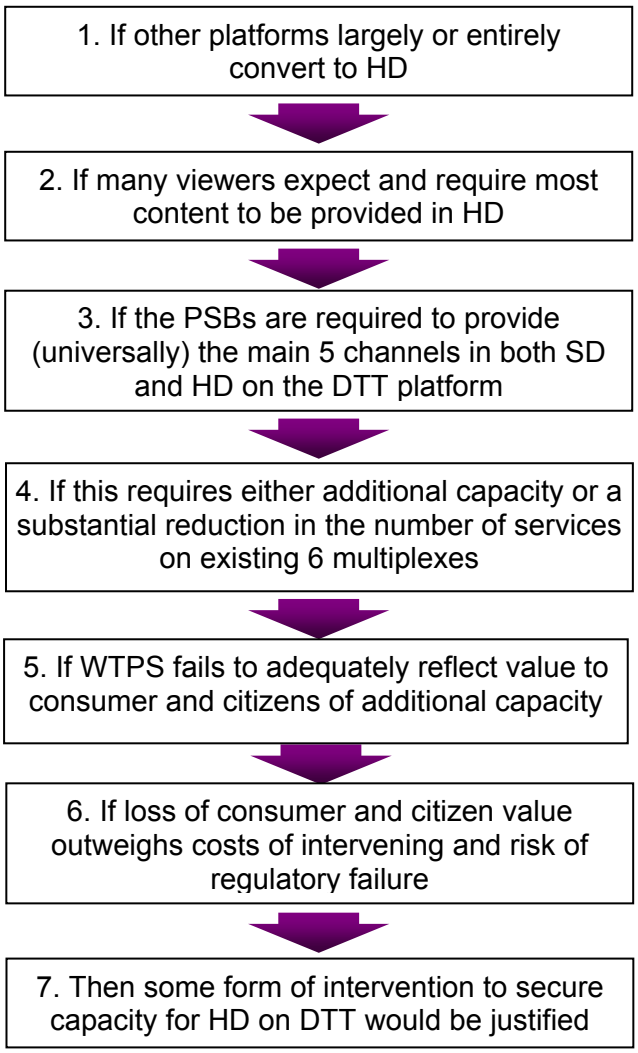
A8.426 Technical evolution is a persistent characteristic of all broadcasting services. Over the last fifty years terrestrial broadcasting has evolved from black and white to colour, from analogue-only to a combination of analogue and digital, from free-to-view to a mix of free and pay and from linear broadcast channels to linear integrated with interactive and on-demand services. Any potential future transition from SD to HD is just one more example of this kind of technical evolution, and is not in itself a market failure that requires regulatory intervention.

A8.427 Absent co-ordination difficulties (which we assess earlier to be insufficient to cause a market failure) there would generally need to be a source of external value (ie externality), which results in the incentives of DTT providers and operators not being aligned with the value to consumers and citizens, for a risk of market failure to be present in this situation.

A8.428 The additional considerations which are relevant to the potential market failure argument in relation to the availability of PSB content in HD are as follows. The DTT platform has a statutory responsibility to deliver universal access to the five main public service channels. Although many viewers watch public service channels via cable or satellite, the requirement to provide near-universal access to PSB content (in standard definition) is assigned by the Communications Act (and subsequent decisions) explicitly to the terrestrial platform. If viewers' expectations evolved to the point where they expect PSB content to be universaly available in HD, it might become necessary for the PSBs to simulcast the main five channels in standard and high definition for a sustained period in order for this universal access requirement to be met.

A8.429 Therefore, if the result of the award of the available UHF spectrum is insufficient capacity on the DTT platform to broadcast the main five PSB channels in both SD and HD, we would need to be clear that this was not because the broadcasters had been unable to take into account any broader social value associated with provision of the PSB services in HD. Put another way, in order for an efficient award of the available UHF spectrum to occur, it would be important for the PSBs to be able to adequately reflect the value to society which may be generated by using additional capacity to offer PSB content universally in HD, relative to alternative options (such as using existing capacity or considering alternative delivery platforms if future statute allows this). If PSB operators are unable to adequately reflect the broader social value which could be generated in their bids for spectrum, this could result in a market failure. The logic of this argument is set out in Figure 8.11.

Figure 8.11 Scenario in which a transition to HD requires intervention to secure additional capacity on DTT platform to allow universal access to PSB content



A8.430 The following section discusses the evidence for and against these arguments that was collected in the DDR.

Evidence gathered by the DDR

Technical analysis

A8.431 The six existing DTT multiplexes currently provide 32 national free-to-air TV services to around 73% of UK homes, plus additional pay-TV services, interactive services and radio stations.

A8.432 The amount of TV services that these multiplexes are able to carry has increased as technical capabilities improve, and is expected to continue to do so up to switchover. By the end of switchover, it is possible that the number of standard definition channels available on the six multiplexes could increase to approximately 49 as a result of the change in transition mode from 16QAM to 64QAM on the

remaining multiplexes (which is expected to increase the overall DTT capacity by 24 Mbits, the equivalent of an additional DTT mux) and the better use of existing capacity (using the MPEG2 compression standard). The three public service multiplexes, with 98.5% coverage of UK homes, could be expected to carry up to 24 standard definition channels; the commercial multiplexes, expected to have around 90% coverage, could provide up to a further 25. Alternatively, some of that additional capacity made available by the mode change could be used to launch HD services on DTT. Roughly speaking, each HD channel will require at least the same bandwidth as three standard definition channels[37].

A8.433 Ofcom has carried out some modelling of possible scenarios to test whether the creation of additional DTT capacity on the existing six multiplexes could allow the main five public service channels to be simulcast in HD and SD without loss in capacity for other channels currently carried on the existing multiplexes. One complicating factor is that not all multiplexes will have the same coverage after switchover – the intention is that the PSB multiplexes should reach 98.5% coverage, matching the existing coverage of analogue terrestrial TV. The coverage of the commercial multiplexes is in some respects for their commercial operators to determine, but is assumed here to reach around 90%. Currently, around 73% of homes are estimated to be able to receive all six multiplexes.

A8.434 If it were deemed necessary for the coverage of the main five PSB channels in HD to be near-universal, in the absence of another universal coverage multiplex, they would have to be accommodated on the three public service multiplexes. Our analysis suggests that this would be possible, but up to six of the ITV, Channel 4 or BBC channels currently broadcast on the public service multiplexes would need to be displaced to the commercial multiplexes. Note that these displaced channels would still have greater coverage on those multiplexes than they do at present, because of the expansion of the coverage of the commercial multiplexes at switchover; but they would not be universally available. The displaced channels could be accomodated on the commercial multiplexes without any further displacement of services, due to the additional capacity available following mode change at switchover.

A8.435 Alternatively, the public service channels in HD could be sited on the commercial multiplexes. This would allow them to achieve 90% coverage, which is not universal coverage, but would still make them available to the vast majority of viewers, including many who cannot receive any DTT services at present; the remainder of the population would be able to use alternative platforms, such as a free-to-view satellite service or an IPTV service, to receive public service content in HD. In this scenario, some of the channels currently located on the commercial multiplexes would move to the PSB multiplexes. None of the channels currently on the PSB multiplexes would need to move.

A8.436 In either of these scenarios, our analysis suggests that the main five public service channels could indeed be simulcast in HD on the existing six multiplexes, with a level of coverage greater than current DTT coverage. In addition, it would be open to the multiplex operators and broadcasters to provide further HD channels on those multiplexes, if they felt doing so would offer greater value to viewers and advertisers than SD channels. For example, up to three additional HD channels could be launched if the number of SD channels were reduced by nine.

[37] It is assumed that HD services will operate using MPEG4 compression technology.

A8.437 It is worth noting that providing HD on the DTT platform would also require substantial technological change. The digital terrestrial platform currently uses MPEG2 compression technology. However the MPEG4 format offers significantly more efficient compression, and may become the standard for TV broadcasting in future, particularly if take-up of HD services, which require MPEG4 compression, becomes widespread. MPEG4 is already in use, for example, in BSkyB's HD satellite services.

A8.438 A move from MPEG2 to MPEG4 (for SD services) would roughly double the capacity of the DTT platform, with significant benefits to society. However, the digital terrestrial receivers currently in UK homes are not MPEG4-compatible, and therefore a change to MPEG4 would have a significant cost. Consumers would need to change their set-top boxes for MPEG4 boxes, or fit MPEG4-compatible boxes to their integrated digital TVs. These receivers would be backwards-compatible with MPEG2, so they could also be used to receive services that continue to be broadcast in MPEG2.

A8.439 Assuming consumers do not all change simultaneously, the number of channels available to consumers with MPEG2 boxes would be reduced by the use of capacity for broadcasts in MPEG4. Arguably, it would be easier to effect a transition to MPEG4 by ensuring more capacity is available for the DTT platform to enable transmission of MPEG4 services in addition to the existing MPEG2 services.

A8.440 From a consumer perspective, if HD services were launched on the DTT platform, whether on the existing multiplexes or a hypothetical seventh multiplex, consumers would need to replace their existing set-top boxes with new, MPEG4-compatible boxes, for any TVs on which they want to watch HD transmissions. Consumers with integrated digital TVs would also need to acquire new HD set-top boxes or adapters.

A8.441 It is also possible that viewers would need to acquire and install new aerials, if the HD services were broadcast on new capacity and the frequencies used were out of group for their existing services. It is unclear how many viewers could be affected by this, since it would depend on which frequencies were used by any additional DTT multiplexes.

Market research

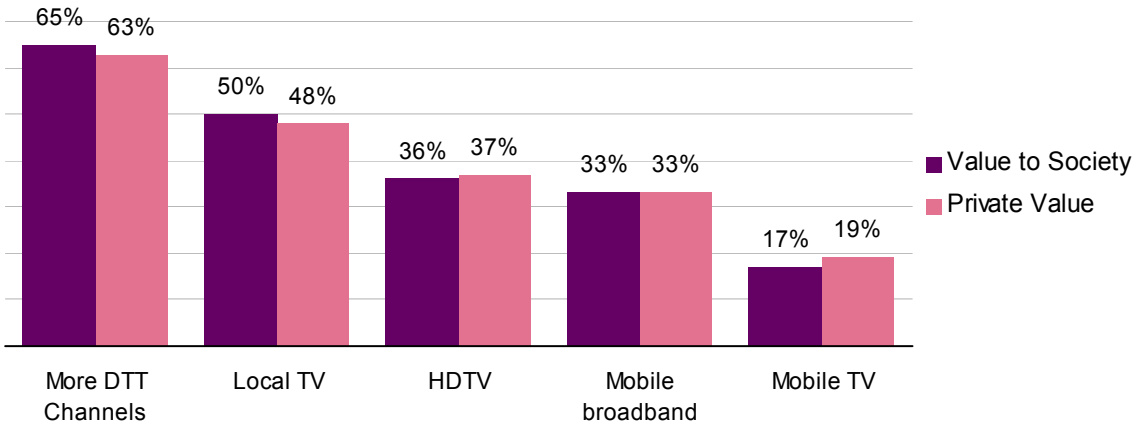
A8.442 Any future transition from SD to HD on the DTT platform will rely on viewers: their enthusiasm for HD content, their willingness to acquire new equipment and potentially switch platforms to get it and the extent to which they view it as an essential, rather than a 'nice-to-have', feature of the content that they value most highly.

A8.443 Market research offers an indication of the value that viewers **currently** attach to HDTV. Market research carried out for the DDR indicates that at present HDTV is of interest to a minority of UK viewers, with 23% describing it as 'essential' or 'very beneficial'. Two-thirds of this group already subscribe to cable or satellite packages (not necessarily HD packages), which means that around 8% of viewers watch terrestrial services on their main set and think that HDTV is essential or very beneficial.

A8.444 Ofcom's qualitative research found that currently many viewers see HD as a 'luxury' or niche product, rather than a service with universal appeal. Perhaps because of this, at present consumers in our research did not place as high a value on HDTV

services as on an increased choice of channels on the DTT platform. This can be seen in Figure 8.12 below.

Figure 8.12 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

A8.445 Similarly, most viewers also currently feel that the broader social value associated with HDTV is relatively low. In ranking a number of statements relating to the public availability of services, availability of HDTV was considered on average less important than availability of internet connections for schools, local news and programmes, more standard definition channels on DTT and more wireless broadband. Compared to other services that could use the available UHF spectrum, consumers say that the additional broader social value delivered by HDTV represents a small proportion of its total value.

A8.446 However, it is uncertain how much insight current market research offers into consumers' and citizens' views of the value of HDTV in future. It is inherently difficult to research consumers' views of a technology which, for the most part, they have not yet experienced. Currently only around one in six UK households has a TV with a screen size of 30" or more, and many of these are not HD-compatible.

A8.447 It may be that consumers systematically over-estimate the value of services that they are already familiar with (such as additional free-to-view channels) and under-estimate the value of services that are present taken up only by a minority (such as HDTV). It is possible therefore that as HDTV becomes better established and more widely taken up that many more viewers, including viewers on the DTT platform, will start to see HDTV as a necessity rather than a luxury.

A8.448 Research from the technical trial of HDTV on the DTT platform, carried out jointly by the BBC, ITV plc, Channel 4 and Five, provides further evidence.[38] This research was carried out with volunteers who had already bought HD-ready displays, so may

[38] See http://www.bbc.co.uk/info/policies/pdf/dtt_hdtrial.pdf

not be typical of the wider population. On the other hand, it does provide insight into the views of consumers more familiar with HDTV.

A8.449 This research found that HD had broad appeal, with no significant differences between different age groups and genders. The quality of HD pictures was rated 8.9 out of 10, on average, as opposed to 5.9 for SD pictures; the genres that were seen to have benefited most were wildlife, sports and films.

A8.450 Seven in ten (71%) triallists believed that HD will become standard for all TV, and 86% said it was 'very important' that HD was available on Freeview. The majority thought BBC One and Two, ITV1, Channel 4, five and FilmFour should, at a minimum, be in HD.

Stakeholder engagement

A8.451 In the stakeholder engagement exercise carried out for this study, the public sector broadcasters argued that HDTV is a long-term necessity for the DTT platform to survive, on the assumption that other platforms will move to HDTV in the future. Several broadcasters stated that offering a small number of high-quality channels (ie, HDTV) would be more important than offering many lower-quality ones (ie, SDTV).

A8.452 They argued that spectrum should be used for additional multiplexes in the released spectrum to allow them to offer HDTV. This is because the existing multiplexes will continue to broadcast the DTT channels in SD, and because any HDTV channels will need to be broadcast simultaneously. Stakeholders did not view using capacity on the existing multiplexes as a credible option for HDTV..

A8.453 The public service broadcasters would like their PSB obligations to be recognised when designing the award of the available UHF spectrum, particularly regarding any coverage requirements, and have concerns about a purely commercial auction. They argue that the same broader social values that apply to SD public service channels also apply to the use of the spectrum for HDTV. It was argued that other platforms would not realise the full value of HDTV to society, because:

- the satellite and cable platforms reach less than 98%+ of homes (due to small buildings not permitting satellite dishes and the limited penetration of cable); and
- it will be difficult to deliver a HDTV channel (which will require around 8Mbit/s) via broadband given that a large proportion of the population lives more than 2km away from a local exchange (which will limit the speed offered via DSL).

A8.454 It was also argued that if HDTV was not offered it may hinder the development of the HD television set market in the UK.

Demand analysis

A8.455 There are two questions to resolve with respect to the evolution of the market for HD services. The first is the extent to which the cable and satellite platforms will become wholly or predominantly HD. The second is whether, if pay platforms did become all-HD, the DTT platform would become unviable as a commercial proposition if it did not make a similar transition.

A8.456 No platform is completely unconstrained by capacity; there are limits to bandwidth, even on high-capacity platforms like cable and satellite. Therefore the question is

whether the cable and satellite platforms would, over time, deliver better returns by minimising the amount of SD services they broadcast in order to maximise the total number of HD channels available. The total number of channels would be lower than the alternative of only providing SD services, but they would be provided at a higher quality.

A8.457 How to make this trade-off depends partly on viewers' enthusiasm for the new technology and equipment, as discussed in the previous section. However, it also depends on sufficient content being available to feed a large number of HD channels. At present there is not enough HD content available to support more than a few channels, and it is notable that most of that is provided by Sky (which has an incentive to maximise the supply of content to encourage take-up of its HD services), the BBC and one or two US broadcasters with a large volume of content generated for their home markets. Very few UK broadcasters are producing or commissioning large volumes of content in HD at present, although clearly this may change in future as the market develops.

A8.458 A key issue will be whether the production industry will move to HD production within the next few years. The BBC has already confirmed that it intends to move to HD-only production within this timetable. Whether the rest of the industry (both within the UK and overseas) moves to HD production in a similar timeframe will be a key factor in enabling the cable and satellite platforms to largely switch to HD. If this transition to HD production does not happen on a wide scale, it may be that even those with HD-compatible equipment may have to be accustomed to watching a mix of HD and SD for some time.

A8.459 International experiences of growth of HD may provide some insight. Although other markets are very different to the UK's, with different drivers of growth and TV consumption, it is interesting to note that in the US – where HD has been available since 1998 – penetration of HDTV was forecast to reach 20% of households by the end of 2006. In Japan, where HD was pioneered in the 1980s, just 5% of homes were expected to have HD services by the end of 2006. In both markets, less than half of all homes with an HD-compatible set were actually subscribing to HD services in 2006. However, it should be recognised that there is tremendous interest in moving to HD among many broadcasters and elements in the broadcast supply chain (including retailers and manufacturers). It is possible that HD will become the standard for much broadcasting in say the next 5-10 years.

A8.460 If the cable and satellite platforms did make the transition to an all- or mostly-HD model, and the DTT platform did not make a similar transition, would the DTT platform become unviable? It is likely that DTT's competitive position against other platforms would become weaker, because presumably in this scenario many viewers could be sufficiently attracted to HD to switch to cable or satellite platforms, even if this meant taking out a subscription package. However it is also likely there would be some HD services on DTT in this eventuality; HD services could be accommodated on the existing multiplexes, as described above, if they offer more value to viewers than existing or potential new SD services. Given the large installed base of DTT receivers in UK homes, it is uncertain whether the DTT platform would become unable to compete with all-HD cable and satellite networks. In any event, so long as there is a statutory and public policy commitment to the provision of the main PSB services on the terrestrial platform, it is extremely unlikely that the DTT platform would become unviable – though the extent to which costs fall for PSBs as against non-PSBs may change.

Economic modelling

A8.461 As discussed earlier, at present only a minority of viewers have first-hand experience of HDTV. This makes the analysis of the private value (producer and consumer value) to be derived from HD particularly uncertain, as the consumer value depends on several future trends that may be only in their early stages.

A8.462 Our modelling supports a finding that the situations where a broadcaster would be willing to pay the highest amounts for spectrum are the same ones in which the consumer value is highest. Both private value and willingess to pay for spectrum increase when the proportion of viewers on the DTT platform who own HDTV sets increases, and when consumer tastes shift to HD significantly.

A8.463 As long as the demand for HD materialises, the modelling shows that there is producer value in deploying a HD multiplex. The modelling work shows that the value which could be generated by using the available UHF spectrum to increase the capacity of the DTT platform in order to allow additional HD content to be shown is reflected in both willingness to pay for spectrum and consumer value.

A8.464 Finally, our analysis of external value indicates that currently broader social value generated by HDTV is not disproportionately large relative to other services competing for the available UHF spectrum. However, as discussed earlier, this may change in the future if HD becomes a widely accepted standard. However, in that case, the broader social value generated will be driven by the public service content which is available and watched in HD rather than because of the HD format itself.

Assessment of the case for intervention

A8.465 The following paragraphs assess each of the possible arguments for intervention outlined above, based on the evidence collected in the DDR. This analysis seeks to establish whether there is reason to believe that the factors identified would, in fact, mean that a market-based approach to the award of the available UHF spectrum would be likely to result in a suboptimal outcome for society.

A8.466 This section does not attempt to assess the benefits and costs of any potential remedies; nor does it discuss whether these remedies would be an appropriate solution to any problems identified. These issues are covered in a separate section..

A8.467 This section first considers whether the advent of HD as a widely used standard changes any of the findings reached above in relation to the effects on the DTT platform of the availability of additional capacity, and then considers whether there could be broader social values generated by the availability of universal access to PSB content on the DTT platform which may not be reflected in the willingness to pay for spectrum.

Effects on the DTT platform

A8.468 The DTT platform might find it more difficult to make the transition to HD, compared to the cable, satellite and broadband platforms. This is because of its fundamental technical characteristics. DTT uses very scarce and valuable low frequency spectrum to convey signals, not wires, like cable or broadband, and not abundent high frequency spectrum like satellite. As a result the DTT platform has inherently lower capacity than the other platforms, and most of the currently available capacity is already in use. DTT platform operators therefore face more acute trade-offs

about how to use their capacity than the operators of other platforms. During a transition from SD to HD broadcasters would need to make decisions on when to transition their channels from SD to HD, and whether to simulcast their content during this transition.

A8.469 This choice will have an impact upon viewers: viewers with HD-compatible equipment would benefit from broadcasting in HD, but those without would lose value if channels are not simulcast. Additionally, broadcasters may need to incur the cost of buying out other operators with existing contracts to use multiplex capacity and may generate little additional advertising revenues on simulcast HD channels (as, even where HD channels can charge a premium for advertising, these are likely to largely replace the same revenues on existing SD channels). However, as long as the value generated for viewers is reflected in the incentives of DTT providers and operators such that when there is an increase in consumer value from switching a channel from SD to HD there is also a commercial incentive to complete this transition (either using existing capacity or by acquiring additional capacity) we would not expect this transition to occur in an inefficient manner.

A8.470 Therefore, absent co-ordination difficulties (which we assess earlier to be insufficient to cause market failure) there would generally need to be a source of external value (ie externality) which results in the incentives of DTT providers and operators not being aligned with the value to consumers and citizens for a market-failure to be present.

A8.471 The same logic holds for the transition from MPEG2 to MPEG4, which as discussed above is related to the transition from SD to HD, as HD content will generally be provided using MPEG4.

A8.472 There are three questions that need to be addressed with respect to a putative transition to MPEG4:

- whether such a transition likely to take place;
- whether additional capacity required to deliver it; and
- whether there are reasons to suggest that intervention may be required to secure it.

A8.473 These arguments have not been considered in detail in the DDR. However, we suggest that the answers to these questions are insufficiently certain to justify intervention at this point. There is no public policy to support a transition from MPEG2 to MPEG4 broadcasting on the DTT platform. The number of MPEG2 set-top boxes already in the market means that any transition to MPEG4 in the short- to medium-term would come at a substantial cost.

A8.474 Furthermore, there is a variety of ways such a transition could be effected, many of which would not require additional DTT capacity. For example:

- Multiplex operators could effect a more rapid switch to MPEG4 by providing consumers with new MPEG4 boxes. To the extent that this would provide commercial benefits to the operators of the DTT multiplexes they could take this into account in assessing the costs of providing new boxes.
- The market may make the transition to MPEG4 organically, through marketing MPEG4 boxes (which are backwards compatible to MPEG2) and highlighting the

added benefits of MPEG4, which could include access to high definition services. This would allow a relatively smooth albeit elongated transition with minimum disruption to viewers.

A8.475 The arguments for the presence of external value which could result in a market failure in relation to the use of the available UHF spectrum for HD services are largely a reprise of the arguments that were assessed in the previous section in relation to the possible weakening of the DTT platform as a competitor if it does not acquire additional capacity. The question is whether the advent of HDTV creates any **additional** risk, over and above the issues discussed above, that a market-based award of the available UHF spectrum would not result in its socially optimal allocation.

Figure 8.13 Assessment of effects of HDTV market failure arguments on the DTT platform

Argument	Assessment
Bids for additional capacity will fail to take account of the reduction in the efficiency of the use of the existing DTT spectrum if viewers were to switch away from DTT because of lack of capacity	There do not appear to be any strong reasons why the advent of HD on the DTT platform would change the assessment of this argument as set out in Figure 8.9 above
Bids for additional capacity will fail to take account of the detrimental impact upon competition in broadcasting services if the DTT platform becomes weaker because of lack of capacity	There do not appear to be any strong reasons why the advent of HD on the DTT platform would change the assessment of this argument as set out in Figure 8.9 above
Bids for additional capacity will fail to take account of the impact of the DTT platform becoming weaker without additional capacity on the realisation of public policy goals such as universal access to PSB content (in SD)	There do not appear to be any strong reasons why the advent of HD on the DTT platform would change the assessment of the argument in relation to whether the public policy goal of universal access to PSB content (in SD) may not be achieved because of a weakness in the DTT platform. (The arguments around universal access to PSB content in HD are discussed later in this annex) There is an additional argument that consumers have come to expect a high quality offering on the DTT platform, particularly in the context of switchover, and will suffer if the platform's ability to keep up with cable and satellite is compromised after switchover. This argument could apply if the DTT platform were unable to offer sufficient HD services. In the case of the commercial broadcasters there do not appear to be strong reasons why they would not be able to reflect the value to consumers of the availability of HD on the DTT platform in their decisions over whether to transition their channels from SD to HD on this platform. Therefore, where consumer expectation of the quality on the DTT platform translates into high levels of consumer demand for HD services on this platform, this would be reflected in the incentives of commercial broadcasters to transition their channels from SD to HD
Bids for additional capacity will fail to take account of the impact of additional capacity	There do not appear to be any strong reasons why the advent of HD on the DTT platform would change the assessment of this argument as set out in Figure 8.9 above

on supporting the funding of public service television	

Broader social value of universal access to PSB content in HD

A8.476 As set out above the case for intervention in relation to this argument is based upon the logic flow set out in Figure 8.11. Our analysis shows that there are reasons to be uncertain about each line in this logic flow, and we address each point in turn in the following paragraphs.

A8.477 ***Other platforms convert to HD:*** In the short- to medium-term, it is uncertain whether other platforms will convert largely or entirely to HD. On the supply side, even the cable and satellite platforms are limited in capacity at some level, and the operators face a choice between maximising the number of services on the platform and moving to a somewhat smaller number of higher-quality channels. They are also constrained by the availability of HD content. While the BBC has already confirmed that it intends to move to HD-only production within this timetable it is unclear whether the rest of the industry (both within the UK and overseas) will move to HD production in a similar timetable .

A8.478 ***Consumer demand for HD content:*** Ultimately, the evolution of the HD market will be driven by consumer demand for HD, the extent of which is currently uncertain. HD currently is a relatively expensive proposition, requiring consumers to pay a premium both for compatible TV sets and pay-TV subscriptions. This is reflected in the research carried out for the DDR, in which only one in four viewers described HD as 'essential' or 'very beneficial'; many 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. Willingness to pay for additional DTT services including HD was also relatively low, and the number of HD channels was less important in driving consumers' preferences for DTT than factors such as the number of SD channels available. In addition, it is uncertain whether consumers will demand HD for all forms of content, or whether demand will be limited to the types of content which particularly benefit from the higher picture quality, such as sports, films and wildlife documentaries.

A8.479 However, HD is a new service, and many viewers currently have little knowledge or experience of it. We must be wary of extrapolating future behaviour from current perceptions. As the market develops, and the technology becomes more familiar, it is likely that interest will grow and attitudes will change. We sought to explore this in our research by looking at the attitudes of those who already have HD or know a lot about it. These may be early adopters, with unrepresentative interest in and enthusiasm for the added benefits of HD; but it is still instructive that 66% of these viewers see HD as essential or very beneficial.

A8.480 Therefore it is possible that consumer demand could grow significantly, and that this could happen relatively quickly. Digital TV has reached over 70% of homes in just eight years, and although HD is not taking off as quickly as digital TV did, it could still reach a large market over the next few years. 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.

A8.481 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 come to

expect and require most content to be available in HD, including the main five public service channels.

A8.482 There is therefore a great deal of uncertainty regarding the development of consumer expectations for HDTV. 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.

A8.483 ***PSB Strategies:*** Our analysis suggests that there are a number of strategies the PSBs could use to make HD services more widely available that are not dependent on the acquisition of additional spectrum. Different strategies are likely to have different costs and benefits for the PSBs, for example in terms of implementation costs, effects on market share and on revenue.They are also likely to have different costs and benefits to viewers, for example with respect to effects on choice, competition and cost of access.

A8.484 We have identified a number of potential strategies, but it is likely that other options exist as well. Moreover, those options we have identified are not mutually exclusive, which means that there is likely to be a range of different approaches that could be taken. The use of additional spectrum is one of these, but only one. A number of these options would allow the PSBs to offer their five main services in HD terrestrially and/or using other platforms to over 90% 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 a 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.

A8.485 These options are summarised in thefigure below. The discussion of these options is not intended to be comprehensive. There are also options not listed (such as use of new platfroms, such as broadbands-based IPTV).

Figure 8.14 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.

A8.486 It is clear from thefigure 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 be used individually or in combination to meet this expectation. One of the options is that some of the available UHF spectrum is used for a new (7^{th}) multiplex, which could carry HD services. However, the other options do not involve the use of additional 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.

A8.487 ***Reduction in number of services without additional capacity:*** If some of the new capacity created by technological improvements on the existing multiplexes were used to launch HD channels instead of further SD channels, our analysis shows that the main five public service channels could be made available to around 90% of homes without loss of access to any of the existing channels on the DTT platform. This would involve rearranging the six multiplexes, so that PSB services in HD were carried on the commercial multiplexes.

A8.488 If the existing PSB multiplexes were used to carry the five main PSB services in HD, this would make those services available to 98.5% of the population terrestrially. However, the capacity of these multiplexes is limited, and HD is bandwidth hungry, so the total number of SD services available on these multiplexes would fall to around 10 (five of which would probably be the main PSB channels, simulcast in HD). This reflects the fact that the DTT platform is most capacity constrained where it is providing near-universal coverage (ie at the 98.5% level), which in turn reflects the scarcity of the “best quality” (widest coverage) spectrum.

A8.489 If the PSB broadcasters wanted to achieve higher coverage than 90% for their services in HD, a further option would be to expand the coverage of the commerical multiplexes. Our analysis suggests this could be increased to a maximum of 96% without requiring significant extra spectrum (additional assigments would be needed in the interleaved capacity but typically in areas of low population where there is little or no scarcity). This would involve extra transmission costs. It would however also extent the availability of other services carried on the commercial multiplexes.

A8.490 If additional spectrum were used for a further multiplex with universal coverage, some of which could be used for HD or for SD services displaced from the existing six multiplexes, this would increase the number of services available, although not to the level that there would be if the multiplexes were used solely for SD.

A8.491 These options are summarised in Figure 8.15 Note that this is only a small set of the many possible permutations of the capacity available after switchover.

Figure 8.15 Scenarios for the provision of HD content on the existing six multiplexes and a hypothetical new multiplex

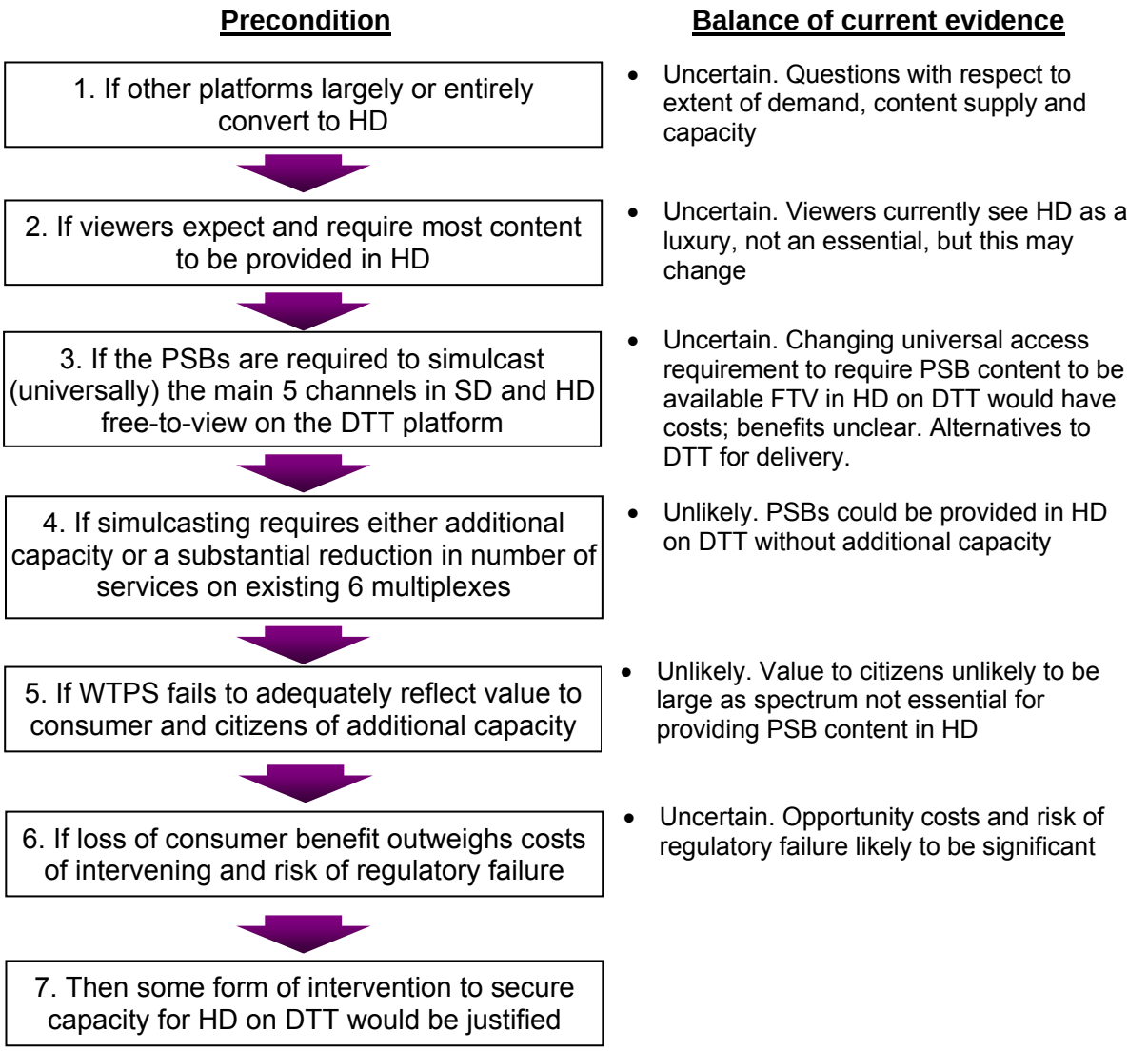
Scenario	73% of homes (currently covered by DTT)	90% of homes (will be covered by all six multiplexes after switchover)	8.5% of homes (will be covered only by PSB muxes after switchover)
1. Existing position	**32 SD**	**-**	**-**
2. 2012 if all capacity is used for SD	**-**	**49 SD & 0 HD**	**24 SD & 0 HD**
3. 2012 if 5 HD channels provided to 90% of homes	**-**	**35 SD & 5 HD**	**24 SD & 0 HD**
4. 2012 if 5 HD services to 98.5% of homes	**-**	**35 SD & 5 HD**	**10 SD & 5 HD**
4. 2012 as 3 plus additional spectrum is used to provide a further universal coverage multiplex	**-**	**43 SD & 5 HD**	**18 SD & 5 HD**

A8.492 ***Risk of market failure:*** Our analysis suggests that the risk of a market failure in relation to the universal availability of PSB services in HD is unlikely to be large. If broader social value were to be realised from the universal availability of these channels in HD, there is a variety of different ways in which that value could be delivered to society.

A8.493 The benefits of additional spectrum are not the benefits of providing access to the PSB services in HD on DTT. The benefits are driven by how many additional channels over and above the PSB services could be provided. DTT providers will have the opportunity to compete in the award process to obtain additional spectrum. If additional capacity for HD or SD services is important to the platform than this could be reflected in a higher willingess to pay for spectrum. The broader social value of use by PSBs can also be reflected in their willingness to pay provided the financial and institutional regime allow this.

A8.494 Figure 8.16 summarises the uncertainties surrounding the development of HDTV and the likelihood that the DTT platform will require additional capacity to meet changing public service requirements. Taken as a whole, it seems unlikely that the conditions requiring additional capacity to be made available for DTT on a preferential basis will be met.

Figure 8.16 Summary of assessment of the case for intervention



A8.495 The following section assesses in more detail whether, given this uncertainty, setting aside spectrum for additional DTT capacity at this stage is the most appropriate way of managing the various risks involved.

Opportunity cost of spectrum

A8.496 The opportunity cost of a seventh multiplex to enable provision of the public service channels in HD on the DTT platform, without loss of other standard definition channels, would be relatively high or very high depending on the coverage required.

A8.497 A technical plan could be developed for a seventh multiplex that would have 98.5% coverage. However for that plan to be consistent with the frequency plans established by the RRC in 2006 would require the use of the 12 of the 15 channels cleared at switchover. The opportunity cost of this capacity is likely to be very high, given the existence of a wide range of other candidate uses.

A8.498 It is possible that a multiplex with coverage at or close to 98.5% could be designed in a way that uses less spectrum. However such a plan would not be consistent with frequency assignments agreed at the RRC. Therefore it would require further international negotiations with neighbouring countries, likely to include France, Belgium, the Netherlands and the Republic of Ireland. These negotiations could be protracted, and would not give the broadcasters the certainty that they would like that a near-universal multiplex would be delivered.

A8.499 Alternatively, it would be possible to design a seventh multiplex using five or six of the cleared channels which achieved near-universal coverage. However, depending upon the particular channels used, this option could potentially result in a significant number of homes needing to acquire new aerials to receive the new services on such a multiplex, since its frequencies would be out of group for many existing aerials. However, the opportunity cost of this option would still be relatively high.

A8.500 A further alternative to extending coverage would be to extending the coverage of an existing commercial multiplex to achieve universality of coverage. The opportunity cost of spectrum of this option could be very low.

Potential remedies, benefits and costs

A8.501 We have concluded that the case for intervening to deliver more capacity for high definition DTT is uncertain. However, even if we were to find that there was a case for seeking to ensure that DTT providers were able to secure additional capacity for high definition TV after switchover, it is unclear that intervening in spectrum markets would be the most appropriate way of achieving that objective.

A8.502 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 in Section 6. 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.

A8.503 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.

A8.504 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.

A8.505 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.

A8.506 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.

A8.507 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.

A8.508 The larger the intervention made, the greater the risk of regulatory failure, and in this case uncertainty about the future development of HD content and the DTT platform creates a significant risk of regulatory failures. It is possible that we could:

- over-estimate future consumer demand for HD, or preferences for DTT vis-à-vis other platforms;
- be wrong about the need for universal access to PSB content in HD;
- under-estimate the potential value to society of alternative uses of the spectrum, including uses that may not yet have been identified;
- distort competition within DTT and between platforms by enhancing the position of the public service broadcasters;
- reduce incentives to ensure the maximum possible use of the existing six multiplexes; or
- reduce innovation, by creating less scope and weaker incentives for new uses of the spectrum.

A8.509 Rather than directly awarding the spectrum to DTT providers, we could set the terms of the auction in a way that benefited DTT providers, but did not exclude potential other uses and did not remove incentives for efficient use entirely. For example, bidder credits could be offered to providers who undertook to use the spectrum to provide universal access to the main five channels in HD on the DTT platform.

A8.510 This is a more transparent and measurable form of support than direct grants of spectrum. It would not definitively exclude other uses; if other uses have sufficient willingess to pay for spectrum to outbid DTT providers despite their bidder credits, they would be deemed the most valuable use and awarded the spectrum.

A8.511 However this approach still has many of the disadvantages of direct spectrum grants. Given uncertainty over the level of future demand for HD it would be difficult to set the correct level for the credits. And bidders will still have misaligned incentives, since they would not have paid the true price for the spectrum they would use.

A8.512 The third alternative to intervening in the award of spectrum is to ensure that a suitable institutional and funding framework to enable the PSBs to acquire the resources they need to most effectively meet consumers' and citizens' changing needs, whatever they might be. Those resources could be spectrum; they could be additional capacity on existing multiplexes; they could be a universally available "freesat" service; they could be services delivered via broadband.

A8.513 It is beyond the scope of the DDR to discuss this in detail. However, in principle this approach would mitigate the uncertainty associated with projecting future consumer demand for HD content, and the value to consumers and society of different future uses of the capacity, by giving the broadcasters adequate resources to continue to fulfil public service goals in a digital environment, and the flexibility to use them – within a suitable regulatory regime – in the most effective and efficient way, whatever that turns out to be in light of market and technological development over the next few years.

A8.514 This proposal would also ensure that the PSBs recognise the true cost of spectrum when deciding how much to use. It would give them incentives to get the right balance between spending money on spectrum and on programmes or other costs. It would reduce the risk of regulatory failure, since the spectrum licences would be flexible, and there would be no barrier to changing the use of the spectrum if circumstances changed.

Ofcom's proposal

A8.515 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 set aside digital dividend spectrum for HD on DTT.

A8.516 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 to society of this spectrum.

Annex 9

Economic modelling

A9.1 This annex provides an overview of the economic modelling work which has been completed to inform our assessment of the total value to society which could be generated by the available UHF spectrum. This modelling work has included assessments of the private producer and consumer value which may be generated by the different potential uses of the spectrum and has also included an assessment of the possible magnitude of external values[39] which may also be generated (this analysis is based upon the market research Ofcom commissioned in 2006 as discussed in the market research report which is published alongside this document, available at http://www.ofcom.org.uk/consult/condocs/ddr/mktresearch/).

A9.2 The issues which are discussed in this annex are as follows: our methodological approach to the modelling work, the approach taken to modelling producer and consumer value for each service, the approach taken to assessing external value, and a summary of the key results of the modelling work.

A9.3 Please note that, for the reasons set out below, **none of the numbers presented in this document can be taken as an indication of auction proceeds**.

Methodology

A9.4 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. This modelling has involved the construction of a suite of models which allows 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 willingness to pay for spectrum of individual operators and of the private producer and consumer value which may be generated from the use of the spectrum (the willingness to pay for spectrum numbers are not reported in this document).

A9.5 The services which have been modelled are: mobile multimedia, Digital Terrestrial Television (DTT) (standard and high definition (SD and HD)), local TV, programme making and special events (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 limited information on the nature of these uses.

A9.6 In addition we have conducted market research to assess the possible magnitude of the external value which may be generated by some of the potential uses of the spectrum (it has not been possible to complete market research in relation to PMSE use as this does not generally involve the provision of services directly to consumers). This work should be considered in conjunction with results of analysis of external values completed by our consultants (as discussed in their report which is published alongside this document, this is available at http://www.ofcom.org.uk/consult/condocs/ddr/report_analysys/).

[39] See Annex 7 for a discussion of the different sources of value which are relevant to our assessment of the value to society.

A9.7 Important methodological considerations which have influenced our modelling work are the presence of significant uncertainty over how markets might develop over the timeframe of the modelling work and the need to consider the *incremental* effect of using the available UHF spectrum on the value generated (which is likely to be smaller than the absolute value generated by many of the services owing to the availability of substitutes eg alternative spectrum or delivery platforms).

A9.8 The private value models which have been developed have been designed to take account of the significant uncertainty over how the markets might develop. Amongst the many uncertainties are:

9.8.1 Will HDTV become a widely adopted standard or will it be a more limited product, which is of value only for specific forms of content?

9.8.2 How high will demand for mobile multimedia content be and what will end-users demand it for (live content versus pre-downloaded)?

9.8.3 What difference will having local TV over the DTT platform make relative to alternatives, such as delivering over the internet?

9.8.4 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?

A9.9 In the face of these uncertainties, amongst many others, we have constructed models which allow estimates of private producer and consumer value to be made for a very wide range of plausible future "states of the world". This allows us to consider how the uncertainty might impact upon the range of values generated. The high level of uncertainty and the complexity of some of the inter-relationships between services mean that this type of modelling can only reasonably be expected to inform an order of magnitude assessment of value and so figures presented in this annex should not be interpreted as precise estimates.

A9.10 Our methodological approach to identifying the incremental value which is generated by using the available UHF spectrum compared to other alternatives has involved considering, for all the potential uses, the range of alternatives they could draw on 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 values with and without the UHF spectrum. For example, the incremental value of using the available UHF spectrum to provide mobile multimedia services takes account of the availability of alternative substitute spectrum bands for the provision of these services in the absence of UHF spectrum (such as L-Band). This approach of assessing incremental value makes an important difference and explains why the lower end of the range shown in Figure 9.1 below is in some cases quite low or even zero.

A9.11 As mentioned above, the models which have been constructed allow estimation of the willingness to pay for spectrum of individual operators and of the private producer and consumer value which could be generated. Producer and consumer value is the sum of industry producer surplus (profits) and consumer surplus (individual's willingness to pay in excess of the market price). 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.

A9.12 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 and the broader social value generated by these services may change over time as they become more widely available;
- it can be difficult for individuals to fully appreciate the value a service generates for society); and
- the questions asked in the consumer market research in some cases differ from the incremental level of service used to quantify the private producer and consumer value (for example the research asked about the value to society of mobile TV as a whole, whilst our assessment of producer and consumer value measured the value of using the available UHF spectrum to deploy these services rather than alternative spectrum bands).

A9.13 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.

A9.14 The range of producer and consumer value generated from the use of the spectrum is reported in Figure 9.1 below, as are the indicative estimates of the range of external value associated with these services. 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.

A9.15 It is therefore important to recognise that none of the numbers quoted in this document can be taken as an indication of auction proceeds. This is for a variety of reasons including the following.

- The private producer and consumer value includes all value generated for both producers and consumers.
- The producer value we have modelled is total producer value, including the impact on other producers operating in relevant markets, rather than the producer value generated by the potential bidder alone.
- The producer value generated by a potential bidder is the maximum they should be willing to bid in an auction. The amount a bidder will have to pay (ie auction proceeds) will be determined by the design and rules of the auction, and the market circumstances at the time of the award. Auction proceeds will likely only be a proportion of the producer value of the winning bidder.

Approach taken to modelling producer and consumer value of each service

A9.16 Set out below is a discussion of our approach to modelling the private producer and consumer value of each of the services. This discussion details the business case

modelled, the approach taken to assessing incremental value, and the key variables which have informed our modelling.

A9.17 Our modelling of each of the services has looked at a wide variety of different scenarios based on plausible combinations of key variables to identify estimates of high and low values for the producer and consumer value which could be generated from the use of the spectrum. These different scenarios can be thought of as different feasible states of the world. Although we examine high and low-value scenarios for each service, we have not sought to encompass the full range of possible outcomes[40]. For example, our high-value scenarios are generally conservative, ie scenarios in which services would generate even greater value can be envisaged.

A9.18 The producer and consumer value models all use a 20 year modelling period from 2008 to 2027 and provide discounted value results expressed in 2008 pounds.

Mobile multimedia

A9.19 The business case for mobile multimedia services is driven by projected demand for high quality mobile TV. This is an emerging service and as such the uncertainty surrounding future demand is particularly large. This was reflected in our modelling by using several demand scenarios. These include scenarios where interest in the service is high, low, and a scenario where interest eventually becomes high after a slow start.

A9.20 In assessing the incremental value of using available UHF spectrum the modelling takes account of other available alternatives for operators interested in the service. For instance:

9.20.1 Most existing mobile operators are currently able to offer mobile TV services via their 3G networks but if the service is offered in this way and if it proves popular, these networks may become congested without additional spectrum.

9.20.2 Another alternative is to use some other spectrum band, such as the L-Band. There are, however, reasons why UHF spectrum may be more valuable than substitute spectrum:

- If, for instance, UHF was widely used across Europe whilst alternative bands (such as L-Band) were only used in a limited number of countries, this could lead to a wider range of equipment (including handsets) becoming available for the UHF band at lower cost.

- In addition, in some geographical areas, the coverage properties of UHF spectrum compared to alternative, higher frequency, spectrum bands could result in lower network rollout costs.

A9.21 The states of the world which were considered for mobile multimedia were built using various combinations of inputs across the following different variables. The information provided below includes illustrative examples of the levels which these

[40] This is reflected in the range of producer and consumer value reported in this document which is significantly narrower than the range presented by our consultants in their report, which is available at http://www.ofcom.org.uk/consult/condocs/ddr/report_analysys.

variables were assumed to take but does not provide an exhaustive list of all input levels which were considered.

- The level of demand for mobile multimedia services: from niche demand only for specific types of content (for example, news or sports) to high (mass market) demand.
- Alternatives to digital dividend spectrum: from existing 3G networks to other dedicated spectrum bands.
- The population coverage level of networks: from deploying networks covering urban areas only to networks with rural coverage in addition to their urban coverage.
- The number of operators in the market: from one to five.
- Degree of harmonisation: from European harmonisation around the UHF spectrum band for mobile multimedia services to no harmonisation.
- Timing of launch: from 2008 to 2012.
- Amount of spectrum required: from 8MHz to 24MHz per operator depending on the number of programming channels offered and the type of network deployed (single frequency network or a multi-frequency network).

A9.22 Taking these variables into account we identified the following as scenarios in which the producer and consumer value generated by this service could be at plausibly high and low levels.

A9.23 **High value scenario:** There is high demand for mobile multimedia services, but mass market use of broadcast technologies is delayed due to technology adoption issues. The UHF band evolves to be the dominant band across Europe (resulting in economies of scale for UHF equipment/handsets). As a result two operators rollout using UHF spectrum in the UK in both urban and rural areas (one from 2008 and another from 2012). Another operator rolls out a network using L-Band spectrum in 2008. If UHF spectrum is not available these operators rollout using alternative technologies/spectrum at higher cost. Each UHF operator acquires at least 8MHz of spectrum to offer 24 mobile TV channels (two 8MHz channels per operator if an MFN is required). Whilst operators are waiting for UHF spectrum to become available they make use of capacity on existing 3G networks to provide a restricted mobile multimedia service to their customers.

A9.24 **Low value scenario:** There is niche demand for mobile multimedia services (demand and coverage is limited to urban areas). Two operators rollout mobile multimedia networks in 2008; one using UHF spectrum and one using alternative spectrum. The UHF operator enjoys lower equipment costs due to some degree of European spectrum harmonisation around this band. The UHF operator acquires at least 8MHz of spectrum to offer 24 mobile TV channels (two 8MHz channels if an MFN is required).

DTT – SD and HD

A9.25 There are several types of bidder that could be interested in launching a new multiplex dedicated to additional SD or HD services. These include a broadcast network operator, a broadcaster, or a consortium. Our modelling attempted to cover

all of these possibilities by examining the economic incentives for a notional combined entity of broadcaster and network operator.

A9.26 The future demand for both SD and HD services on the DTT platform may be strongly influenced by changes in consumer tastes, driven by the introduction of HDTV. As consumers buy larger HDTV sets and as more programmes are broadcast in HD, consumers may gradually value HD more than they presently do. Similarly, current SD services may look too blurry on a large HDTV set and viewers may come to value SD channels less than they do at present.

A9.27 Important drivers of the incremental value of using the available UHF spectrum for DTT services therefore include:

9.27.1 The level of consumer demand for HD and any impact upon the value of SD channels to consumers.

9.27.2 The impact of changes in consumer demand upon the services offered over existing DTT multiplexes and on alternative platforms. If demand for HD is strong, it is plausible that existing DTT multiplexes may launch HD channels, possibly at the expense of current SD capacity.

A9.28 The states of the world which were considered for HD and SD DTT were built using various combinations of inputs across the following different variables. The information provided below includes illustrative examples of the levels which these variables were assumed to take but does not provide an exhaustive list of all input levels which were considered.

- the consumer taste for HD varies from low demand scenarios where HD is a niche segment appealing only to a minority of viewers, to high demand scenarios, where HD is preferred by the majority of viewers and SD is perceived as being inferior to HD. As a result the proportion of viewers interested in HD by the end of the modelling range from 50% to 100%.

- The number of SD and HD channels available in the future on the existing multiplexes in the absence of digital dividend spectrum: this ranged from offering no HD channels (i.e. only SD channels) on the existing multiplexes to transitioning these multiplexes to be entirely HD by the end of the modelling period.

- The number of additional multiplexes: from one to three.

- The level of population coverage achieved by additional multiplexes: from 40% to 98.5%.

- Business model of operator: free-to-view or subscription service.

- Spectrum requirements: 8MHz to 112MHz per operator depending on the type and number of multiplexes deployed.

A9.29 Taking these variables into account we identified the following as scenarios in which the producer and consumer value generated by this service could be at plausibly high and low levels.

A9.30 **High value scenario:** One or two additional multiplexes are deployed with each using five or six 8MHz channels. Each multiplex offers three new HD channels (or

8 new SD channels) with broad population coverage (in the region of 95%). The consumer value of incremental channels (HD and SD) is relatively high (but still conservative). If UHF spectrum is not available the DTT platform is constrained to a maximum of 5 HD channels (or up to 48 SD channels). For the high value scenario for HD, demand for HD is polarised (50% of the population have a strong preference for HD by 2012). For the high value scenario for SD, demand for HD remains low (only 24% of DTT users have any interest in HD by 2012).

A9.31 **Low value scenario:** The assumptions on the number of additional multiplexes, the spectrum requirements and hence population coverage, and the number of channels offered on the DTT platform without UHF spectrum are as with the high value. However, the consumer value of HD is lower resulting in a lower demand for HD. A similar sensitivity was performed to derive a low value for SD. The incremental SD channels to be offered were taken to be channels for which consumer interest is lower than the incremental channels in the high-value case.

Local TV

A9.32 Local TV services could be offered via a variety of different platforms (for example, DTT, cable, broadband or satellite). Therefore, our modelling sought to identify incremental benefits from an advertiser-funded local TV operator offering their services via the DTT platform rather than these alternatives. The key driver of such value was assumed to be the incremental viewers that local TV services gain if the DTT platform is used rather than these other means of delivery.

A9.33 Other drivers of incremental value which were included in our modelling were:

9.33.1 The level of consumer demand for local TV; and

9.33.2 The size of the area targeted by local channels.

A9.34 The states of the world which were considered for local TV were built using various combinations of inputs across the following different variables. The information provided below includes illustrative examples of the levels which these variables were assumed to take but does not provide an exhaustive list of all input levels which were considered.

- The level of demand for local TV services. This ranged from low demand to high demand.
- The penetration achieved if alternative platforms are used in areas where local TV is available: ranges from low penetration (around 10%) to high (around 20%)
- The penetration achieved if the DTT platform is used in areas where local TV is available was assumed to be 50%
- The size of broadcast localities: from small localities (individual masts) to wide areas (the size of main station areas[41]).
- Technical options for delivering local TV services: from deploying a dedicated local TV network to using add/drop on a national DTT multiplex (based on substituting a channel in a national multiplex).

[41] A Main Station Area (MSA) is the area covered by a main transmitter site. There are 51 MSAs in the UK.

- Up to four programming channels in a given area were considered and up to 98.5% population coverage was modelled.

- Spectrum requirements: at least 8MHz of useable spectrum at each location.

A9.35 Taking these variables into account we identified the following as scenarios in which the producer and consumer value generated by this service could be at plausibly high and low levels.

A9.36 **High value scenario:** Demand for local TV is high. If UHF spectrum is not available, local TV services are not offered on the DTT platform and coverage for local TV over other platforms is more limited. However, in those key areas where local TV channels are available the uptake is relatively high. If UHF spectrum is available two programming channels are offered per MSA via a dedicated local TV multiplex using a single 8MHz spectrum channel in each location. The rollout extends to maximise producer and consumer value (resulting in approximately 70% population coverage).

A9.37 **Low value scenario:** Demand for local TV is low. If UHF spectrum is not available, local TV services are not offered on the DTT platform and coverage for local TV over other platforms is even more limited than in the high value case. However, in those key areas where local TV channels are available the uptake is relatively high. If UHF spectrum is available two programming channels are offered per MSA via a dedicated local TV multiplex using a single 8MHz spectrum channel in each location. The rollout extends to maximise producer and consumer value (resulting in approximately 40% population coverage).

PMSE – Professional and Community

A9.38 We have assessed the value of spectrum to PMSE users for two types of organisations: a band manager and a programme maker (a consortium of users willing to buy the spectrum for their own use).

A9.39 When modelling the incremental value of the spectrum for PMSE uses we considered the following two factors:

9.39.1 The level of interest in PMSE services as represented by the type of users and their spectrum requirements (eg national channels and interleaved).

9.39.2 The level of value which PMSE users derive from their spectrum use, hence their willingness to pay for this over alternatives (such as moving to a different spectrum band or economising on spectrum use). There is significant uncertainty around this as current prices are set to cover administrative costs rather than being based on the value which is generated. In assessing value we have considered both the value of equipment which would become obsolete if UHF spectrum were not available alongside other benchmarks for plausible levels of willingness to pay.

A9.40 The states of the world which were considered for PMSE were built using various combinations of inputs across the following different variables. The information provided below includes illustrative examples of the levels which these variables were assumed to take but does not provide an exhaustive list of all input levels which were considered.

- The level of demand was assumed to grow at a steady rate;
- Range of prices users are willing to pay: from low to medium;
- Next best alternative to digital dividend spectrum: migration to another spectrum band or use of wired devices;
- Two different types of bidder and business model: a band manager or consortium of programme makers.
- Type of spectrum: national cleared channels or interleaved spectrum.

A9.41 Taking these variables into account we identified the following as scenarios in which the producer and consumer value generated by this service could be at plausibly high and low levels.

A9.42 **High value scenario:** With available UHF spectrum a band manager buys interleaved channels to lease to PMSE users. Without digital dividend spectrum, PMSE users are forced to migrate to another band, opportunities for which are severely constrained because of spectrum scarcity and equipment incompatibility. The willingness to pay of PMSE users is relatively high (but still conservative).

A9.43 **Low value scenario:** The with and without UHF assumptions are set out above. In the case of UHF spectrum a band manager leases interleaved capacity to users, whilst without UHF spectrum users are forced to migrate (the opportunities for which are severely constrained). However, the willingness to pay of PMSE users is assumed to be lower than in the high value scenario.

A9.44 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 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.

Mobile broadband

A9.45 Our modelling assumed that mobile broadband would be provided as a specialist data only product. Demand for mass market voice and data services was captured in our mobile communications model.

A9.46 The factors which influenced the incremental value of using the available UHF spectrum for mobile broadband were:

9.46.1 The impact of the propagation characteristics of the UHF spectrum on network infrastructure costs for both incumbent operators and new entrants.

9.46.2 The impact of the degree of European harmonisation on the cost of deploying in UHF spectrum compared to other bands.

9.46.3 The level of consumer demand for mobile data services.

A9.47 The states of the world which were considered for mobile broadband were built using various combinations of inputs across the following different variables. The information provided below includes illustrative examples of the levels which these

variables were assumed to take but does not provide an exhaustive list of all input levels which were considered.

- The level of demand for mobile broadband services: from medium demand concentrated in urban areas to high level of demand nationwide.
- The degree of European harmonisation around the UHF spectrum band: from high degree of harmonisation to no harmonisation at a European level.
- The number of operators in the market: from two to four.
- The bidder: either an incumbent operator or a new entrant.
- The level of population coverage was assumed to be 85%
- The purpose of UHF spectrum: for coverage in rural areas only or for urban and rural coverage.
- Spectrum demand: 10MHz to 50MHz per operator.

A9.48 Taking these variables into account we identified the following as scenarios in which the producer and consumer value generated by this service could be at plausibly high and low levels.

A9.49 **High value scenario:** Two existing operators acquire 10MHz of spectrum each to deploy rural networks using UHF spectrum rather than using their 3.5 GHz spectrum holdings (resulting in some delay to rollout). One new entrant acquires 30 MHz of UHF spectrum to rollout in rural areas, which it combines with 30 MHz of 2.6 GHz spectrum for urban areas. There is harmonised use of spectrum across Europe and there is high demand for mobile data services in all geographical areas.

A9.50 **Low value scenario:** Demand for this niche data product is limited to business users in urban areas. The market is not large enough to justify entry and existing operators prefer to use 3.5GHz or 2.6GHz spectrum given the higher bandwidth available at these frequencies and the predominately urban nature of their rollout. Hence, there is no demand for UHF spectrum for this use.

Mobile communications

A9.51 The approach taken to the mobile communications modelling is very similar in structure to that taken for mobile broadband. However the service provided in this model was a mass market voice and data product rather than a specialist data-only service.

A9.52 As with the mobile broadband model, the factors which influenced the incremental value of using the available UHF spectrum for mobile broadband were:

9.52.1 The impact of the propagation characteristics of the UHF spectrum on network infrastructure costs for both incumbent operators and new entrants;

9.52.2 The impact of the degree of European harmonisation on the cost of deploying in UHF compared to other bands.

9.52.3 The level of consumer demand for mobile data services.

A9.53 The states of the world which were considered for mobile communications were built using various combinations of inputs across the following different variables. The information provided below includes illustrative examples of the levels which these variables were assumed to take but does not provide an exhaustive list of all input levels which were considered.

- The level of consumer demand for mobile communications voice and data services: from a medium demand concentrated in urban areas to a high level of demand nationwide.
- The degree of European harmonisation around the UHF spectrum band: from high degree of harmonisation to no harmonisation at a European level.
- Number of operators in the market: from five to seven.
- The purpose of UHF spectrum: for coverage in rural areas only or for urban and rural coverage.
- Spectrum requirements: from 10MHz to 50MHz per operator.

A9.54 Taking these variables into account we identified the following as scenarios in which the producer and consumer value generated by this service could be at plausibly high and low levels.

A9.55 **High value scenario:** Two incumbents acquire 20MHz each and deploy their rural 3G networks using UHF spectrum rather than 2.1GHz spectrum (resulting in some delay to 3G rollout). A new entrant acquires 20MHz of UHF spectrum and 20MHz of 2.6 GHz spectrum to rollout a national network. The 900MHz spectrum becomes liberalised by the time the UHF spectrum is available nationwide and this meets the demands of the remaining existing operators for spectrum to rollout rural networks. There is high demand for mobile voice and data services and there is harmonised use of this spectrum across Europe.

A9.56 **Low value scenario:** The 900MHz spectrum becomes liberalised by the time the UHF spectrum is available nationwide and meets the demands of existing operators for spectrum to rollout rural networks. There is no significant harmonised use of this spectrum across Europe as there are unresolved technical problems with using UHF spectrum for mobile communications. Therefore, there is no demand for UHF spectrum for this use.

Approach to the assessment of external value

A9.57 As discussed in Annex 7, the total value generated from using the available UHF spectrum may not be fully reflected by private producer and consumer value. External value may be generated by the services using the available UHF spectrum and needs to be considered when assessing the total value of the available spectrum to society.

A9.58 Due to the nature of external value, it is inherently difficult to measure (see discussion of options for measuring broader social value on Annex 7). Our market research incorporated a range of techniques that could be used to form estimates of the external value generated by different uses of the available UHF spectrum.

A9.59 In our market research study, respondents were asked to value and rank different potential uses of the available UHF spectrum from a private perspective and from

the perspective of society as a whole. The difference between the two valuations could indicate the relative magnitude of the external value (compared to the private value) that may be generated by that use of spectrum.

A9.60 The market research responses were collated and analysed to inform possible ranges for external value for each potential use of the available UHF spectrum (with the exception of PMSE, for the reasons noted above) and for the aggregate external value that may be generated by the available UHF spectrum.

A9.61 This analysis should be considered alongside the work undertaken by our consultants, which looked at the presence of external value in some detail. This work, which is available at http://www.ofcom.org.uk/consult/condocs/ddr/report_analysys/ reached the same overall conclusion as those presented below.

Summary of results

A9.62 The figure below sets out for each potential service 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, are based on the high and low value scenarios set out above. These scenarios were 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).

A9.63 Additionally, the figure includes an estimate of the possible range of spectrum requirements for each of these uses. As can be seen from this, the high and low values for each service are not additive – there is insufficient UHF spectrum available to meet all potential sources of demand.

A9.64 The figure also presents our estimates of the external value that may be generated by use of the available UHF spectrum. It is not possible to provide an indicative estimate of the external value which may be generated from PMSE as, owing to the nature of this use, it was not included within our consumer market research.

Figure 9.1 Summary of results by service

Service	Range of producer and consumer value	Range of spectrum requirements (total for this service)	Indicative range of external value (as a % of producer and consumer value)
Mobile multimedia	£0. 3bn - £3bn	8 – 48 MHz	Up to 10%
DTT – 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	£1bn - £3.5bn	24 – 112 MHz (using a multi-frequency network) (8 MHz per multiplex would be possible	Up to 5%

		using a single frequency network)	
Local TV	£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)	£0.1bn - £0.5bn[42]	8 MHz of cleared spectrum (preferably channel 69) and up to 32 channels of the interleaved	n.a. (this service was not covered by the market research)
Mobile broadband	0 - £2.5bn	0 – 56 MHz	Up to 15%
Mobile communications	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.

A9.65 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 spectrum required by each service. Overall the biggest source of uncertainty lies in the difficulty in predicting the future markets for the various services, a number of which are nascent. The degree of uncertainty is such that no single service emerges from our modelling work as clearly the highest value.

A9.66 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.

A9.67 In relation to external value, our consultants completed a detailed assessment of this source of value. This assessment 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 this service was considered, the level of external value was found to be significantly lower. The results of this work are consistent with the estimates of external value presented in the figure above. However, the consultants work highlighted that, when further consideration is given to the sources of broader social value and the availability of alternative platforms and substitute bands, the external value generated by local TV may be higher than that suggested by the results in the figure above and the external value generated by mobile communications may be lower than that suggested.

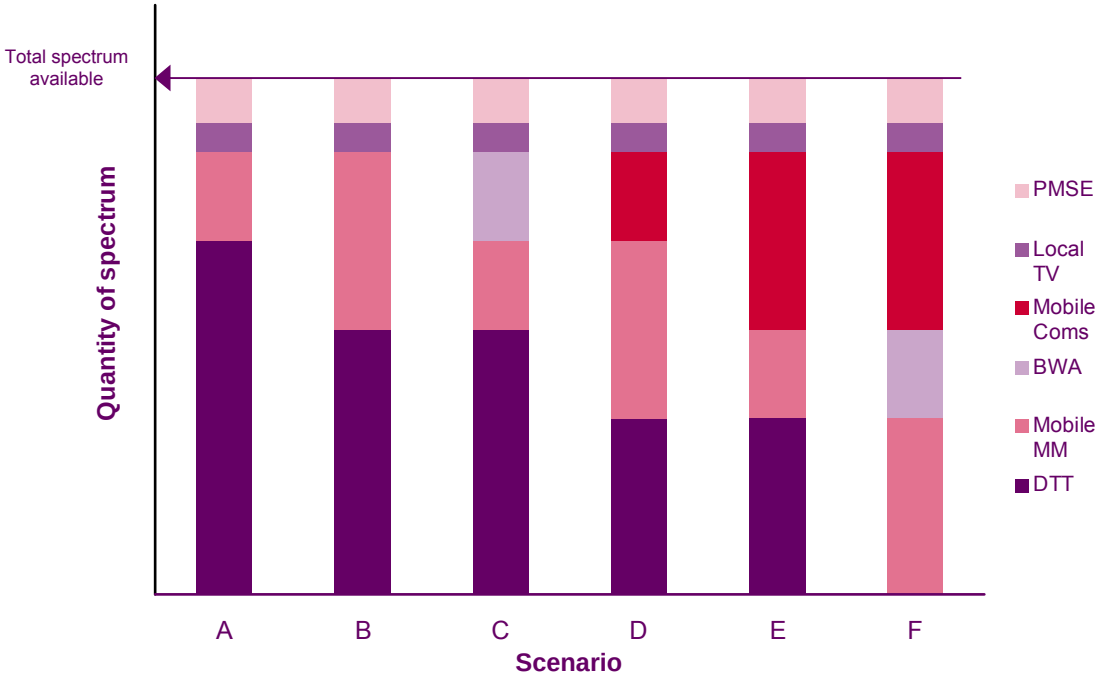
[42] For the reasons set out above our estimate of the producer and consumer value of PMSE may understate the true value. Therefore, this should be taken into account when interpreting these results.

A9.68 The ranges of consumer and producer values shown in Figure 9.1 assume that each service would obtain its entire spectrum requirement in each of the low- and high-value scenarios. However, it is clear from the range of spectrum requirements that there is insufficient available UHF spectrum to accommodate all of the services at their maximum spectrum requirements. Given this finding of excess demand for the available spectrum, we have given consideration to the combinations of services and spectrum requirements that could be accommodated and the aggregate value from the use of the available UHF spectrum.

A9.69 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.

A9.70 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 9.2 Some illustrative combinations of the use of this spectrum



A9.71 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.

A9.72 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.

A9.73 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.

A9.74 The combinations set out above cannot therefore be considered to be a prediction of the likely outcome of an award of the UHF spectrum.

Conclusions

A9.75 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. There is also significant uncertainty over how the different uses may develop over time and the value which each of the uses may generate.

A9.76 However, the modelling work completed allows us to reach the following conclusions:

9.76.1 The high degree of uncertainty requires consideration of a wide range of assumptions when assessing the value which each use may generate;

9.76.2 Taking account of this uncertainty, the modelling work confirms that there is very likely to be excess demand for available UHF spectrum;

9.76.3 It is plausible that high value to consumers could be generated by a wide variety of uses of the available spectrum;

9.76.4 There are a number of uses that could be the highest value and no single use emerges as clearly the most valuable for society.

Annex 10

Technical issues & constraints

Introduction

A10.1 This annex considers the technical issues that will affect how the various potential uses discussed in the DDR consultation could make use of the UHF band. It also considers how these issues will have to be taken into account by Ofcom when it considers how it should set technical constraints within which the variety of services under consideration within the DDR consultation could operate. These constraints were summarised in Section 3 of the consultation document.

A10.2 This annex considers the following issues:

- spectrum planning matters;
- review of service requirements, for the potential new services including DTT, mobile multimedia, cellular and mobile broadband;
- protection of existing services; and
- discussion of constraints on new services.

A10.3 This annex should be read alongside the related technical work that has been carried out within the DDR project. This work comprises:

- detailed technical analysis and modelling carried out by Aegis Systems Ltd as part of the wider consultancy project led by Analysys, see Ofcom website for full report;
- ERA Technology study of interference to DTT reception from 3G and Wi-Max services in the adjacent and n+9 channels, see Annex 11 for summary and Ofcom website for full report;
- NGW Study - Upper cleared spectrum band & lower cleared spectrum band, see Annex 11 for summary and Ofcom website for full report;
- extrapolation of NGW Study - Mixed cleared spectrum band, see Annex 11 for summary;
- LS telcom Study – Local DTT multiplex in interleaved spectrum, see Annex 11 for summary and Ofcom website for full report; and
- Sagentia Study – PMSE services in interleaved spectrum, see Annex 11 for summary and Ofcom website for full report.

Spectrum planning matters

A10.4 Digital switchover is scheduled to take place in the UK between 2008 and 2012 (2013 in the Channel Islands). This process will ensure that all of the currently licensed analogue broadcast and ancillary services operating within the UHF band will cease operation by the end of 2012. The six digital terrestrial television (DTT) multiplex services which are currently broadcast within the UHF band will continue

to be broadcast but at higher powers and (in the case of the three public service multiplexes) at a significantly greater number of sites. These services will in future only be broadcast within the retained part of the UHF band, that is using channels 21 to 30 and 41 to 63.

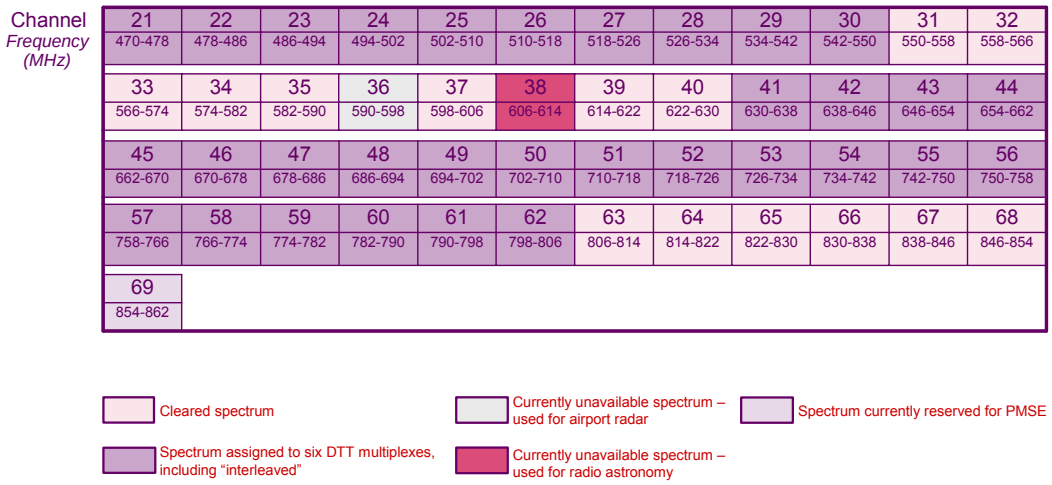
A10.5 There are therefore two areas of the UHF band which will be cleared for new services. These comprise eight channels in the middle of the band (channels 31 – 40 (not including 36 & 38)) and six channels at the top of the UHF band (channels 63 to 68).

A10.6 The DDR is also considering how other parts of the UHF band could be more effectively utilised. These include:

- channel 36, currently mainly used for airport radar;
- channel 69, currently used for PMSE (radio microphones); and
- interleaved spectrum, that is any capacity within the spectrum retained for DTT services not required to ensure that these meet their licence obligations (this is also referred to as "white space" by some users).

A10.7 Figure 10.1 below summarises the spectrum that being considered by the DDR project.

Figure 10.1 Summary of DDR spectrum



A10.8 In order to allow any new service to make use of the cleared or interleaved UHF spectrum it is necessary to both characterise the service requirements for each individual service and to identify any necessary constraints that may be required in order to protect other services using the UHF or adjacent bands.

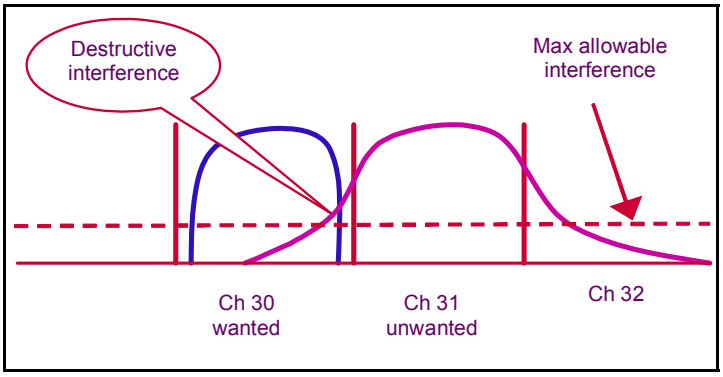
A10.9 These necessary constraints relate to the need to protect other licensed services operating in, or adjacent to, the UHF band either within the UK or in neighbouring countries. Interference between services is normally expressed in three forms:

A10.10 **Co-channel** interference relates to a situation where a frequency channel being used by a wanted service in a particular location is also being used by another service in a different location. The interference can either be continuous or time-varying. In the time-varying case, an interfering signal can under certain

atmospheric conditions (generally high pressure areas) propagate over significantly longer distances than normal resulting in higher levels of interference being suffered for a proportion of the time. Service protection is normally expressed as the percentage of time (typically measured over a year) that the service is fully available (eg DTT services are typically protected for 99% time, cellular and analogue television services for 95% time).

A10.11 **Adjacent channel** interference is caused when a receiver tuned to the wanted service is subject to interference in the wanted channel from another service operating in an adjacent channel (see Figure 10.2 below). If the two services are broadcast from the same location using similar power levels it is relatively easy to define a spectrum mask which would ensure that any interference is non-destructive. However, if the two services are broadcast from different locations and/or at significantly different power levels it is much harder to specify how to protect the wanted service across its entire coverage area.

Figure 10.2 Adjacent channel interference



A10.12 This situation is especially relevant to the protection of DTT services broadcast from a high power/tower transmitter network (which typically employs a relatively small number of sites) from another service operating at medium power using a dense network. The relative field strength of the service broadcast using the dense network signals could be significantly higher than that of the high power network near the edge of its coverage area, due to the different propagation distances from the transmitters. This can result in destructive adjacent channel interference (referred to as hole punching) to receivers close to the transmitters used in the dense network.

A10.13 **Image channel:** Interference results from the use of a particular type of receiver design (called “super heterodyne”) which is used by all DTT receivers which makes them vulnerable to interference from other services being broadcast nine channels above the wanted (DTT) channel. This can cause similar hole punching problems as adjacent channel interference does (see above) although in general measurements show that DTT receivers are less susceptible to image channel interference than to adjacent channel interference.

A10.14 **Mobile stations:** The DDR project has considered the use of a wide range of services including those which will need to employ an in-band uplink signal from the users handset. These services can include for example mobile cellular services (eg 3G) and mobile broadband for mobile users (eg WiMAX). Any in-band uplink transmissions from the user handset (mobile station – MS) are capable of causing co, adjacent or image channel interference to the reception of other services operating in the UHF band. As the uplink transmitters are integrated into the user’s

handset it is not easy or practical to plan or predict the extent of interference from these transmitters nor identify or adopt measures to minimise or eliminate this interference. This creates particular challenges in planning the use of such services within the UHF band.

A10.15 These matters are discussed in more detail in the consultants report available on the Ofcom website and below. Extensive use has been made of the consultants' conclusions in this annex especially those regarding minimum separation distances and guard bands between services operating on adjacent and image channels.

Review of Service Requirements

A10.16 The service requirements for each type of service are discussed in more detail below. These primarily relate to the spectrum demands and interference constraints of each service being considered, and include:

- what level of incoming interference (co-channel, adjacent or image channel) can the service operate with;
- whether this interference is continuous or time limited;
- how many UHF channels the service may require;
- whether the service requires access to a common set of UHF channels nationwide, or regionally; and
- whether the service requires a contiguous block of UHF channels.

Digital terrestrial television

A10.17 Existing DTT services: Six digital terrestrial television (DTT) services are currently broadcast using the DVB-T standard from 81 terrestrial television transmitting sites around the UK. At digital switchover these multiplexes will be adopting the new high power assignments contained in the Geneva 06 Agreement[43]. Three of the multiplexes (carrying the public service channels) have coverage obligations which require them to substantially match analogue coverage levels and they will therefore be broadcast from over 1,000 additional transmission sites. The remaining three commercial multiplexes are expected to operate from only the current 81 transmission sites although at higher power levels than they currently use.

A10.18 These services have been planned on the basis that viewers receive the DTT signal using a fixed roof-top mounted aerial. For the purposes of this Annex it is assumed that aerials are pointing in the direction of the wanted transmitter station and can therefore attenuate interference from other services away from this axis[44] .

A10.19 For the purpose of determining interference requirements it is assumed that all the current six DTT multiplexes will operate using the 64QAM mode at switchover, this is reflected in the technical service parameters detailed in Figure 10.3 below.

[43] This was developed at a regional Radiocommunications conference organised by the International Telecommunications Union (ITU)

[44] It should be noted that some households also make use of set top antennas which do not have these characteristics, these will therefore be more susceptible to interference than those households using roof-top antennas.

Figure 10.3 Typical DTT technical characteristics

Technical Standard	Technical characteristics	Spectrum requirements	Spectrum mask
DVB-T	8 MHz bandwidth 24 Mbit/sec Use max RRC cleared power Min C/N = 17 dB Median FS = 53dBµV/m Location factor = 70% marginal Location factor = 90% served Time protection = 99%	Requires use of interleaved networks based upon use of existing main and relay broadcast sites	Consistent with current DTT use

A10.20 DTT clear spectrum availability: New DTT services (whether carrying national or local, high or standard definition services) will be assumed to require high power assignments co-located at the existing DTT transmission sites on a multi-frequency network (MFN) planning basis. This means that high power assignments in locations closest to the UK's borders (those on the south and east coasts of England, Northern Ireland and the west coast of Wales) will need to be co-ordinated with the respective neighbouring country.

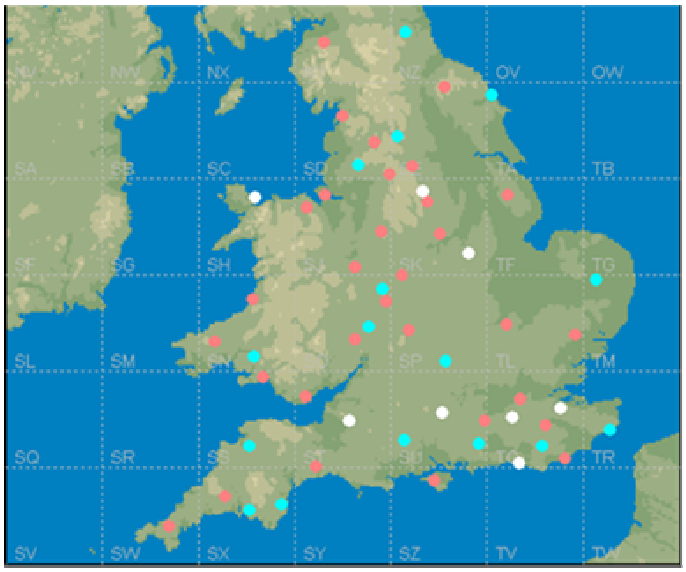
A10.21 The Geneva 06 (GE06) agreement included provision for the UK to operate six DTT networks (referred to as layers by the ITU) within the retained spectrum (these are to be used to allow the broadcasting of the six DTT multiplexes at switchover as discussed above) and two additional layers within the cleared spectrum. The GE06 agreement was concluded on the basis that these two layers would be used for high power DTT services operating from existing DTT transmission sites. The agreement also allowed for these assignments to be used by other types of service (eg mobile television) providing that this use did not result in the service exceeding the interference levels allowed in the agreement for the high power services operating at the specified sites. The assignments attached to these layers were divided between:

- sites which had two assignments in Block 3 (channel 63 to 68);
- sites which had assignments in Blocks 1 & 2 (channels 31 to 40); or
- sites which had one assignment in each of Blocks 1 & 2 and 3[45].

A10.22 This situation is illustrated in Figure 10.4 where the sites with white dots have an assignment in both upper and lower sub-band, those with blue dots have assignments in upper sub-band and those with red dots have both assignments in the lower sub-band. Hence any service which wished to make use of the GE06 assignments at all of the main DTT sites would have to make use of spectrum in both upper and lower sub-bands.

[45] Blocks 1, 2 and 3 are described in Section 9 of the consultation document

Figure 10.4 Showing distribution of GE06 assignments at DTT transmission sites in England and Wales



(source Aegis)

A10.23 It should also be noted that due to the UK's choice of cleared and retained channels the GE06 assignments for the two additional layers at most main station DTT sites will also include one converted analogue assignment. These represent frequencies which are currently used to broadcast the analogue public service channels and which in general would be expected to enable a DTT service operating at that site to match the current levels of analogue coverage from that site. Taken together these conversion assignments would enable one new DTT mux to provide coverage close to that expected from the three public service multiplexes. As discussed above these converted analogue frequencies are scattered across all three Blocks, hence a DTT multiplex which needed to achieve near universal coverage using the GE06 assignments would need to operate across all blocks hence using up most of the available cleared spectrum.

A10.24 The Aegis report noted that if a DTT service were constrained to using only Block 3 then a number of key sites would not have a suitable high power assignment to provide near universal coverage, these include Crystal Palace (London, 10.3 m viewers), Sutton Coldfield (Birmingham, 4.7m viewers) and Emley Moor (West Yorkshire, 3.1m viewers).

A10.25 If DTT services were constrained to using Blocks 1 and 2 then the impact on coverage would be less significant but some major sites in the south east of England would not be included as well as sites at Winter Hill (Manchester, 6m viewers) and Pontop Pike (NE England, 1.7m viewers). The Aegis report proposed two ways in which this coverage shortfall could be addressed for a DTT multiplex operating within only one of the two sub-bands:

- agree new assignments within the wanted sub-band with the UK's neighbours. Any additional DTT assignments outside those agreed by GE06 agreement would require further bilateral agreements with any affected neighbouring countries and would be required to conform to the general requirement that the levels of co-channel interference caused to other planned services do not exceed those allowed under the GE06 agreement. In addition, any new service not using a GE06 assignment would have to be planned on the basis of making allowance

for any incoming interference from other DTT services from the continent or the Republic of Ireland; or

- fill in coverage deficiencies with lower power filler sites operating on frequencies already cleared for use elsewhere in the UK but not exceeding outgoing interference constraints. These would require the extensive use of single frequency network (SFN) fillers which are likely to require a larger guard interval (Aegis proposed using a Guard interval, G_I = 1/8) than used for DTT services today. This would result in a slightly reduced usable bit-rate per multiplex of approximately 21 Mbit/sec.

A10.26 In order to improve its understanding of these planning issues Ofcom has also commissioned some further technical studies from NGW which looked at the opportunities for maximising the potential coverage of DTT services if they were constrained to using either Block 3 or Blocks 1&2. These studies are summarised in Annex 11. Figure 10.5 below summarises the options for using the cleared spectrum for an additional DTT multiplex. Each option has its advantages and drawbacks.

Figure 10.5 Summary of options for additional DTT multiplex for 80 sites only[46]

Criterion	Lower Band Only	Upper Band Only	Mixed Band
Cleared channels Used	Four to Eight channels 31-34, 35, 37, 39-40	Six channels 63-68	Six channels 31-33, 63-65
Predicted Coverage (from 80 Stations)	94% to 96%	95.5%	95%
Receive Aerial Group	Many aerials out of group	Many aerials out of group	Some aerials out of group
Transmission Infrastructure	New antennas & masts may be required	New antennas & masts may be required	Use of existing antennas may be possible
International co-ordination	Required.	Required.	Partially Required.
Remaining Digital Dividend	Six to Ten channels 63-68; 35, 37, 39, 40	Eight channels 31-35, 37, 39, 40	Eight channels 34, 35, 37, 39, 40, 66-68

A10.27 Figure 10.6 below quantifies the stations in and out of the existing receive aerial group for each of the options.

Figure 10.6 Receive aerial group issues

Option	In Aerial Group	Out of Aerial Group
Lower Band Only	50 stations inc London, Glasgow, Birmingham, Southampton	30 stations inc Manchester, Oxford, Bristol
Upper Band Only	27 stations inc Manchester, Oxford, Bristol	53 stations inc London, Birmingham, Glasgow, Southampton

[46] Note that the planned public service multiplexes would expect to cover around 96% of households using these sites

Mixed Band	63 stations inc London, Manchester, Southampton, Bristol	17 stations inc Birmingham, Glasgow, Cardiff

A10.28 In conclusion the NGW and Ofcom studies have shown that it is possible to operate a high coverage DTT multiplex using less than the 12 to 14 channels that the GE06 agreement allocated to the UK. However, it should be noted that the adoption of any of these plans will be subject to the risk that the necessary international agreements will not be forthcoming or if secured may well provide less coverage than is predicted above. It is also important to note that the adoption of any of these options will require a significant number of households to upgrade their aerials to receive a new DTT service.

A10.29 On balance the mixed band option appears to offer the lowest level of international risk and would require the smallest number of households to upgrade their aerials. This option is therefore proposed as being the most appropriate for DTT use when considering issues such as packaging (see Section 9).

A10.30 DTT in retained interleaved spectrum: Despite the denser packing used to make the post-switchover DTT assignments Ofcom considers that it is possible to make secondary use of this spectrum for a small range of compatible services. In order to minimise any interference to the planned six DTT multiplexes these services will have to be compatible with DTT usage. The most appropriate services that meet this criteria comprise additional lower power DTT or mobile multimedia services (these may have to be co-sited with existing DTT transmitters to minimise adjacent channel interference) or low power PMSE use (mainly comprising radio microphones).

A10.31 Ofcom commissioned some research from LS telcom (see summary in Annex 11) to evaluate what type of broadcast services could be operated within this spectrum whilst minimising the impact on exiting DTT services[47]. This research concluded that it was possible to identify up to two low powered assignments (suitable for DTT) at 41 of the 50 main transmission stations currently used to broadcast the six DTT multiplexes with only one assignment being available at a further three sites.

A10.32 In order to ensure that these services do not interfere with existing or planned (post DSO) DTT services certain other restrictions were proposed, including requiring these new interleaved services to operate at a relatively low operating power and that the antenna patterns for these services have significant restrictions in certain directions. These conditions would mean that it would not be possible for any additional DTT services to operate from the omni-antenna used for the six multiplex services at these sites necessitating the need for a new antenna for any of these assignments.

A10.33 Given these restrictions the study assumed that any new services would be operated using a relatively high level of channel coding (error protection) and a robust modulation scheme to ensure a reasonable level of coverage was secured. Accordingly it is assumed that any service using these assignments would be operated using QPSK[48], code rate 2/3. This equates with a usable bit rate of 8

[47] See Annex11 for details of similar analysis of PMSE use in this spectrum

[48] QPSK = Quadrature Phase Shift Key, Code rate refers to the amount of gross capacity that is used for error protection, so 2/3 means that 2/3 of the available bit rate will given over to error coding.

Mbit/sec allowing the carriage of two standard definition television services. The study also considered the use of a less robust modulation scheme equating to a usable bit rate of 24 Mbit/sec; this resulted in a lower coverage.

A10.34 The majority of these assignments would require international clearance with the UK's neighbours. As none of these are included in the GE06 agreement this obviously represents another set of requirements which would have to be factored into an overall UK negotiations strategy for the UHF band. Any use of the retained interleaved spectrum for these additional multiplexes will obviously also diminish the amount of spectrum that is available for other interleaved services such as PMSE. However, the LS telcom study did not find significant conflict between the proposed DTT assignments and PMSE demand except in areas of high demand such as London.

A10.35 Ofcom therefore believes that for the interleaved spectrum:

- ***It is possible to operate one or two additional low capacity and low power multiplexes at a majority of the existing main transmission stations. These would have to operate under significant antenna restrictions meaning that their overall coverage would be considerably less than that of the six existing multiplexes broadcast from the same sites.***

- ***It is possible to increase the capacity of these multiplexes towards that used by the main DTT multiplexes but this would result in further reduction in coverage (by between 15% and up to 66% at each site).***

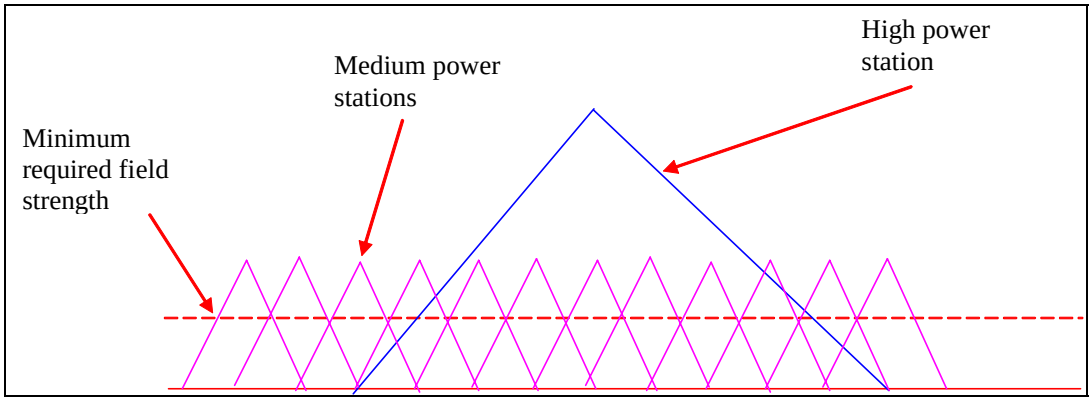
- ***Any such use may require international clearance with the UK's neighbours which would have to be considered as part of a wider UK UHF strategy.***

- ***The use of these frequencies would also affect the capacity available for PMSE applications in the coverage areas.***

Mobile multimedia (medium power)

A10.36 The reception of mobile multimedia services, especially on handheld devices, is expected to require much higher field strengths than can reasonably be delivered using a high power network based upon the current broadcast main station plan. This section will therefore consider the use of a medium power dense network to deliver such services. This type of network is better able to deliver the relatively high field strengths required for indoor reception of services using devices with relatively poor antenna gain and discrimination (see Figure 10.7).

Figure 10.7 Dense medium power network coverage



A10.37 For the purposes of this analysis it is assumed that the mobile multimedia service will be provided using the DVB-H standard. However, the DMB standard (using 3 x 1.7MHz networks in an 8MHz channel) could also be used and would result in very similar technical characteristics and coverage outcomes.

A10.38 The Aegis technical report concluded that a typical DVB-H receiver would require a protection ratio of -27 dB against incoming adjacent channel (n+1) interference and -40dB for other channels (n+m), this means that a typical receiver could still correctly operate with an adjacent channel signal 27dB higher than the level of the wanted signal. The report also considered the use of a -29dB protection ratio for incoming image channel interference. However, it also noted that it expects most mobile multimedia receivers to use direct conversion (ie they will not use an intermediate frequency). Accordingly the protection ratio of -40dB will be used within this report for all non adjacent channels.

A10.39 For the purpose of determining interference requirements it is assumed that a DVB-H service would be operated according to the above criteria, this is reflected in the technical characteristics shown in Figure 10.8 below.

Figure 10.8 Typical DVB-H characteristics

Technical Standard	Technical characteristics	Spectrum requirements	Spectrum mask
DVB-H DMB	**DVB-H** 8 MHz b/w 5 Mbit/sec Typical ERP = 500W @ height of 20m Min C/N 14 dB Median FS = 104dBµV/m	Can either use SFN and single UHF channel for network or interleaved network requiring two or three UHF channels (depending level of incoming interference) Expected to use dense network (similar to GSM900) eg 6,000 sites	Adjacent channel hole punching, requires -29dB protection for adjacent channel protection, -40dB for other channels

Mobile multimedia (High power)

A10.40 Any services that wish to operate at high powers and using high antenna heights are expected to face similar planning and co-ordination issues as would be faced by the new DTT services as discussed above. Accordingly similar planning constraints would be applied to these services. The technical characteristics are expected to be similar to those considered for the medium power mobile multimedia discussed above, these are summarised in the figure below.

Figure 10.9 Typical Mobile multimedia (high power) characteristics

Technical Standard	Technical characteristics	Spectrum requirements	Spectrum mask

MediaFLO	8 MHz b/w 5 Mbit/sec Use max RRC cleared power Min C/N 14 dB Median FS = 104dBµV/m	Requires use of interleaved networks based upon use of main broadcast sites	Consistent with current DTT if using ETSI mask

Cellular (mobile telecommunications) services

A10.41 Cellular telephony systems (and other systems such as mobile broadband) provide the facility for two-way communication. A two way radio system can be frequency division duplex (FDD) based or time division duplex (TDD) based.

A10.42 For FDD systems, one frequency channel is transmitted downlink from a broadcast station (BS) to a mobile station (MS) for instance a subscriber's handset. A second frequency is used in the uplink direction and supports transmission from the mobile station to the broadcast station. Because of this pairing of frequencies, simultaneous transmission in both directions is possible. To mitigate self-interference between uplink and downlink transmissions, a minimum amount of frequency separation must be maintained between the frequency pair.

A10.43 For TDD systems, a single frequency channel is used to transmit signals in both the downlink and uplink directions.

A10.44 Cellular operators in the UK currently operate national networks using two different technologies, GSM and 3G. These networks are predominantly used for voice calls with some data services. The 3G operators use the W-CDMA standard, they have to date focussed on developing their FDD networks. Currently, these systems require a 5MHz channel raster.

A10.45 It is difficult to have a precise view on what systems may be used for cellular services when the DDR spectrum is auctioned. For example, if the spectrum is auctioned in a 8MHz channel raster a future cellular operator may choose to use the 8MHz channel raster for a 5MHz channel, or use two adjacent 8MHz auctioned channels for two or three 5 MHz channels occupying 10 or 15MHz. Alternatively operators may choose to use more flexible OFDMA based systems which would enable them to utilise the full 8MHz bandwidth offered by a single UHF channel.

A10.46 From the 3GPP [49] specification document 25.101 the frequency separation of current FDD systems are listed below (Figure 10.10). It should be noted that this figure and the subsequent discussion relates to current FDD systems. It may be that future systems are able to operate with a more flexible frequency duplex system allowing the uplink and downlink services to operate as little as 10MHz apart. In such circumstances the pairing arrangements would be much more suited to the available blocks of spectrum within the DDR.

[49] The 3rd Generation Partnership Project (3GPP) is a collaboration agreement established in December 1998. The agreement brings together a number of telecommunications standards bodies which are known as "Organizational Partners". The current Organizational Partners are ARIB, CCSA, ETSI, ATIS, TTA, and TTC.

Figure 10.10 Existing 3GPP FDD Tx-Rx frequency separations

Operating Band	TX-RX frequency separation
I	190 MHz
II	80 MHz.
III	95 MHz.
IV	400 MHz
V	45 MHz
VI	45 MHz
VII	120 MHz
VIII	45 MHz
IX	95 MHz

A10.47 These frequency separations have been used to illustrate potential desirable spectrum pairings using the DRR cleared spectrum shown in Figure 10.11 below. The potential pairing cells highlighted in blue are frequencies contained within the DDR released spectrum. The potential pairing cells highlighted in yellow are frequencies within current cellular 900MHz uplink frequency allocation and those in purple are frequencies within the current cellular 900MHz downlink frequency allocation. Channel 38 (marked in red) is used for radio astronomy and which is not available for this application.

Figure 10.11 Possible FDD separations for DDR spectrum

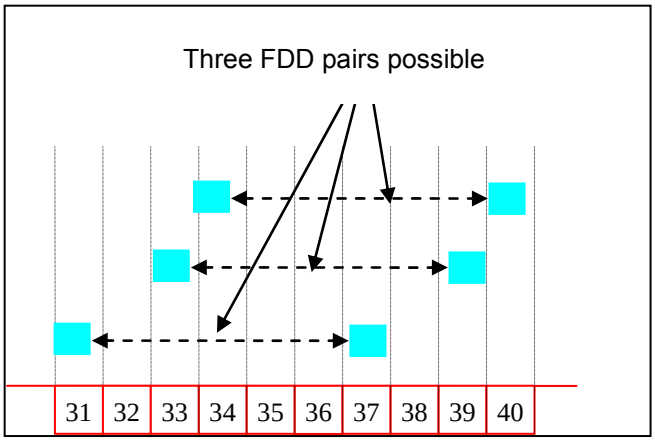
DDR channels available	Lower frequency of DDR channel (MHz)	Lower frequency of duplex pairing for range of possible FDD separations						
		45MHz	80Mz	95MHz	120MHz	190MHz	250MHz	400MHz
31	550	595	630	645	670	740	800	950
32	558	603	638	653	678	748	808	958
33	564	609	644	659	684	754	814	964
34	570	615	650	665	690	760	820	970
35	582	627	662	677	702	772	832	982
36	590	635	670	685	710	780	840	990
37	598	643	678	693	718	788	848	998
38	606	651	686	701	726	796	856	1006
39	614	659	694	709	734	804	864	1014
40	622	667	702	717	742	812	872	1022
63	806	851	886	901	926	996	1056	1206
64	814	859	894	909	934	1004	1064	1214
65	822	867	902	917	942	1012	1072	1222
66	830	875	910	925	950	1020	1080	1230
67	838	883	918	933	958	1028	1088	1238
68	846	891	926	941	966	1036	1096	1246
69	854	899	934	949	974	1044	1104	1254

A10.48 If a FDD system is to use the DDR spectrum for both its uplink and downlink connections, then a duplex spacing of either 45MHz or 250MHz would allow these to fit within the cleared spectrum. It may be more desirable for operators to use frequencies below 750MHz, because above this frequency more filtering may be needed to avoid interference of GSM900 on mobile handsets. In this situation then

it would only be possible to use the 45 MHz spacing hence limiting FDD services to the following pairs of channels (see Figure 10.12 for further details):

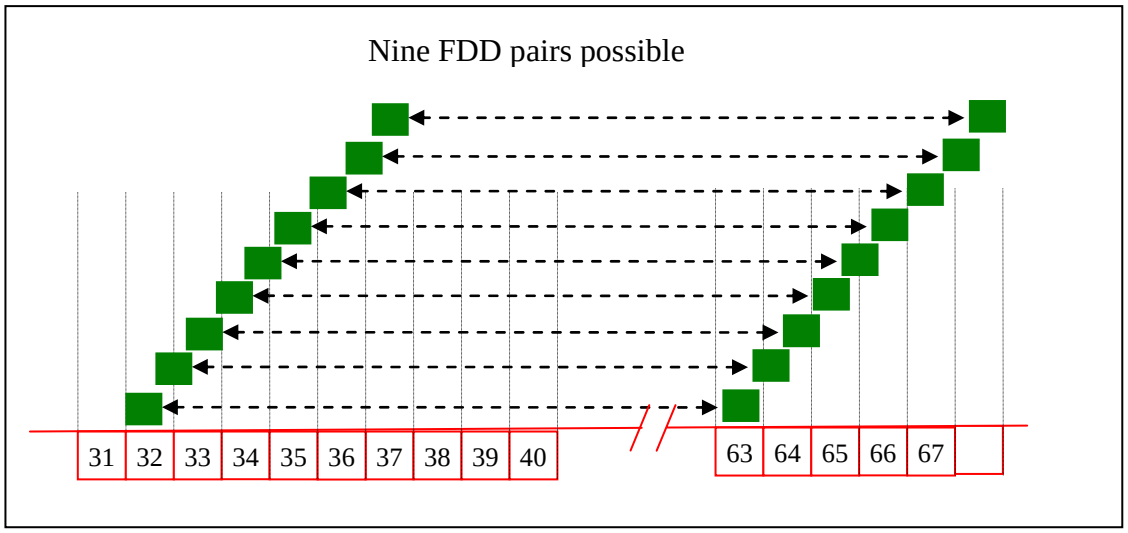
- channel 31 (550 MHz – 555MHz) with channel 36/37 (595MHz – 600MHz);
- channel 33 (564 MHz – 569 MHz) with channel 39 (617 MHz – 622MHz)); and
- channel 33/34 (569MHz – 574MHz) with channel 40 (622MHz – 627MHz).

Figure 10.12 Possible FDD pairs in lower sub-band (45 MHz spacing)



A10.49 If the service was to use both the upper and lower sub-bands it would then be possible to make use of either the 45 MHz spacing as discussed above or a 250 MHz spacing which would then allow the use of nine pairs of channels (see Figure A10.13 for further details).

Figure 10.13 Possible FDD pairs in upper and lower sub-band (250 MHz spacing)



A10.50 As noted above these duplex arrangements only relate to current FDD pairings. If variable duplex technology and OFDMA based systems are utilised this will allow much more flexibility.

A10.51 The technical characteristics of a typical cellular broadcast station and mobile are shown in the figures below.

Figure 10.14 Typical Cellular (Broadcast Station - BS) technical characteristics

Technical Standard	Technical characteristics	Spectrum requirements	Spectrum mask
UMTS – 3G	5 MHz x 2 for FDD based technologies 10 MHz b/w TDD based technologies (3G Long term evolution plans are to have multiple bandwidths up to 20MHz.) ERiP = 500W [C/I = -12dB for BS C/I = -9dB for MS I/N = -6dB C/N = -18dB or -15dB]	Use dense network 6,000 sites for 80% population coverage.	Adjacent & image channel hole punching

Figure 10.15 Typical Cellular (Mobile Station - MS) technical characteristics

Technical Standard	Technical characteristics	Spectrum requirements	Spectrum mask
UMTS – 3G	5 MHz x 2 FDD 10 MHz b/w TDD (3G Long term evolution plans are to have multiple bandwidths up to 20MHz) ERiP = 0.125W [C/I = -12dB for BS C/I = -9dB for MS I/N = -6dB C/N = -18dB or -15dB]	Mobile/handheld device	Adjacent & image channel hole punching

Mobile broadband

A10.52 Broadband wireless technologies are subject to standards developed by both the American IEEE and European ETSI. There are a range of technologies available or being developed within these standardisation bodies. These are predominantly TDD technologies. IEEE 802.16 and the mobile derivative IEE 802.16e can operate with either FDD or TDD, however there is currently more interest in the TDD systems.

A10.53 Small Area Networks typically operate with lower transmit power at higher frequencies. This ensures they have a short range reducing the possibility of interference between uncoordinated networks. System robustness is typically managed by the use of alternative frequencies if the system is subject to interference. The better propagation properties of the lower frequencies make them more suited to the larger Metropolitan and Regional Area coverage networks.

A10.54 The most likely technology candidates for the DDR released spectrum are believed to be WiMAX (IEEE 802.16 and the mobile derivative IEEE 802.16e) and IEEE 802.22.

A10.55 **IEEE 802.16** and the mobile derivative IEEE 802.16e standards are now complete and systems can be developed and implemented using these standards at any frequency up to 60GHz. The WiMAX Forum is the organisation responsible for the conformance testing of the equipment operating with the standards. If a technology meets the conformance requirements as set out by the WiMAX Forum, then it can call itself WiMAX and it is compatible with other WiMAX equipment at that

frequency band. Currently, the WiMAX Forum is focussing on writing conformance requirements for frequencies up to 60GHz, with particular focus on frequency bands where equipment is being developed, these being 3,400 to 3,600MHz and 5,725 to 5,850MHz. The UHF frequencies are highlighted as new bands of interest within the forum and profiles will be specified as spectrum becomes available.

A10.56 **IEEE 802.22:** The IEEE 802.22 standard is being developed specifically with the DDR broadcast frequencies in mind. An important feature of future IEEE 802.22 systems is that they will use cognitive radio techniques, which will enable systems to detect a vacant frequency before transmitting on it, but there are still some challenges involved in specifying a robust cognitive radio system. The aim is to develop an internationally approved IEEE 802.22 specification by January 2008. It is thought that a future IEEE 802.22 technology could either be used for either licensed or licence-exempt applications. It is currently being developed for fixed system applications, and there are no current plans to develop a mobile variant of the technology.

A10.57 Within the Radio Regulations the DDR cleared spectrum has a primary allocation to Broadcasting and Fixed services. Deployment of the fixed variant of a broadband technology is therefore already consistent with the Radio Regulations. A mobile variant of one of the broadband technologies (such as TDD as used by most broadband technologies) would encounter similar interference conformance issues with the Radio Regulations to those for a cellular uplink discussed above.

A10.58 The development of the fixed technology of IEEE 802.22 cognitive radio standard may prove significant in the accommodation of a mobile broadband technology within the DDR spectrum band.

Figure 10.16 Typical mobile broadband (Broadcast Station - BS) technical characteristics

Technical Standard	Technical characteristics	Spectrum requirements	Spectrum mask
WiMAX	Variable number of carriers from 1.25 to 20 MHz. c/i 9dB	Use dense network Uniform power of 500W	Adjacent & image channel hole punching

Figure 10.17 Typical mobile broadband (Mobile Station - MS) technical characteristics

Technical Standard	Technical characteristics	Spectrum requirements	Spectrum mask
WiMAX	Variable number of carriers from 1.25 to 20 MHz. c/i 9dB	Mobile device Maximum power of 0.2W	Adjacent & image channel hole punching

Figure 10.18 Typical mobile broadband (Fixed user Station - FS) technical characteristics

Technical Standard	Technical characteristics	Spectrum requirements	Spectrum mask
WiMAX	Variable number of carriers from 1.25 to 20 MHz. c/i 9dB	Mobile device Maximum power of 500W	Adjacent & image channel hole punching

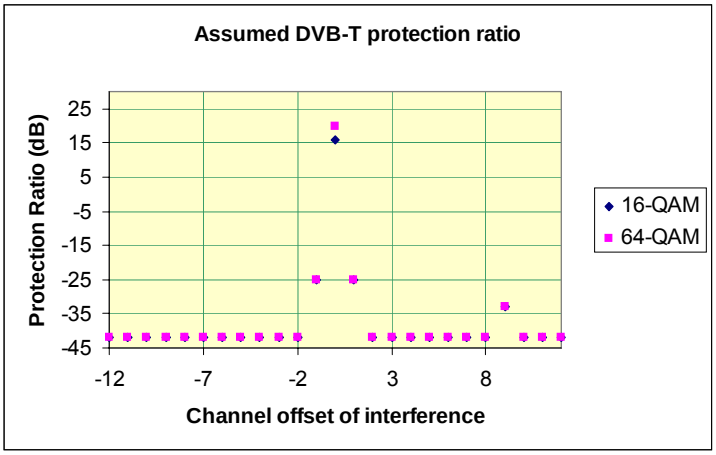
A10.59 It is assumed that any mobile broadband system using the DDR spectrum will operate using TDD. The system is assumed to be operated using an allocation of contiguous UHF channels. Because of uncertainties about the capability of cognitive radio systems to operate within the UHF band it is assumed for the purposes of this technical analysis that any mobile broadband system will be operated using a variant of the 802.16 standard.

Protection of existing DTT services

A10.60 DTT receivers have been sold in the UK since 1998, and are currently estimated to number over 8 million. It is therefore very important to understand how any new service operating in the UHF band could affect reception of the DTT services (broadcast using the retained spectrum) by these receivers (these are referred to as "existing DTT receivers" in the rest of this Annex).

A10.61 The Aegis technical report concluded that the existing DTT receivers required a protection ratio of -25 dB against incoming adjacent channel interference and -34dB for incoming image channel interference, these are illustrated in Figure 10.19 below.

Figure 10.19 DTT receiver response



Source – Aegis technical report

A10.62 This means that the received field strength of any new service operating in an adjacent channel to that used by one of the six DTT multiplexes should not be more than 25 dB higher than the received field strength of the wanted DTT multiplex.

A10.63 Ofcom has recently commissioned ERA to carry out an assessment of DTT receivers susceptibility to this sort of interference, especially when originating from mobile handsets. This work was carried out in November 2006 and the results have only recently become available. The following discussion has not therefore taken this work into account, see Annex 11 for further details.

A10.64 It is possible that the DTT receiver spectrum masks could be made more stringent to give DTT receivers greater protection from such adjacent channel interference. However, this would not help those viewers who currently own a DTT receiver and it is not considered further in this Annex.

A10.65 The Aegis technical report concluded that the hole punching problem would be much greater at the edge of a main station DTT coverage area (where the received field strength is expected to be lower). In this situation (that is near the edge of a main station coverage area) it was proposed that the DVB-H transmitter should be no closer than 600m from a DVB-T receiver. A similar distance of 600m is proposed in the case of mobile broadband/cellular base station, whereas a distance of 300m is proposed in the case of mobile broadband/mobile communications station (handset).

A10.66 It is possible to use a variety of techniques to minimise the impact of any such interference, these include:

- avoid operating on an adjacent channel to the retained spectrum in areas where a DTT service is being broadcast; and

- require that the operator of any new service operating on an adjacent channel to the retained spectrum in areas where a DTT service is being broadcast fixes any interference problems caused, probably by installing additional DTT repeaters at the base station broadcasting the interfering service.

A10.67 Figure 10.20 below summarises the DTT transmitter areas (main stations in italics) and frequencies which may be affected by these requirements.

Figure 10.20 DTT stations operating on adjacent channels to cleared spectrum

Channel 30	**Channel 41**	**Channel 62**
Crystal Palace	*Emley Moor*	*Winter Hill*
Belmont	*Black Hill*	*Pontop Pike*
Caldbeck	*Wenvoe*	*Waltham*
Haslingden	*Sudbury*	*Tacolneston*
Dover Town	*The Wrekin*	*Oxford*
Ramsgate	*Hannington*	*Midhurst*
Aldeburgh	*Redruth*	*Bluebell Hill*
Hastings	*Chatton*	*Huntshaw Cross*
Eastbourne	Tunbridge Wells	*Selkirk*
	Hemel Hempstead	Brierley Hill
	Arfon	Malvern
	Londonderry	Camlough
	Wemouth	Salisbury
	Cambret Hill	Poole
	Newhaven	Limavardy
	Belcoo	Girvan

A10.68 The Aegis report also concluded that there was less chance of interference being caused to the image channel but this assertion requires further evidence to validate.

A10.69 In conclusion this analysis shows that in order to eliminate such interference the received field strength of any new service operating on an adjacent channel to a DTT service should not be more than 25dB higher than the received signal strength of the wanted DTT service. The received field strength of any new service operating on an image channel (eg if the wanted DTT service is broadcast on channel 26 and a new service is broadcast on channel 35) to one of the six DTT multiplexes should not be more than 33 dB higher than the received signal strength of the wanted DTT service.

Compatibility issues with 2-way systems

A10.70 For a 2-way system to use the DDR cleared spectrum, it would need to achieve a sufficient service coverage area to satisfy its commercial objectives. This will depend upon it being able to utilise spectrum which is not subject to too onerous restrictions from international neighbours and will require protection from new and existing services in adjacent spectrum. Any new 2-way entrant in the band would also have to provide a reasonable level of protection to the spectrum already assigned post switchover to the six DTT multiplexes. This issue is discussed in more detail below.

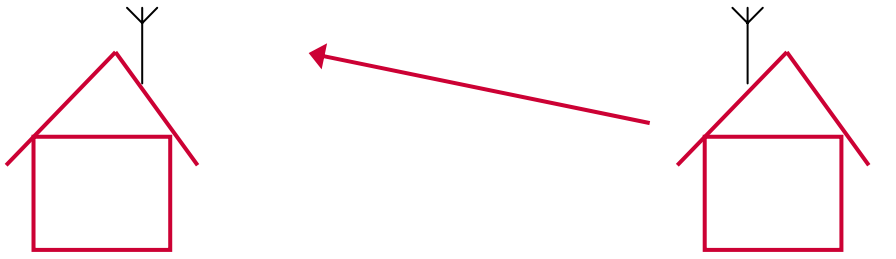
A10.71 Figure 10.21 shows the effect of interference being caused to DTT receivers by signals transmitted from a mobile handset. Figure 10.22 shows the effect of interference caused by a last-mile broadband system uplink transmitter to a DTT receiver.

Figure 10.21 Hole punching scenario mobile terminal causing interference to DTT

A10.72 In this scenario the cellular/mobile broadband terminal is mobile. Co-ordination is not possible in this instance between the cellular/mobile broadband operator and the DTT operator. To maintain existing DTT coverage, a new cellular entrant would have to control interference into DTT services. This could be particularly problematic as the position of the mobile terminal is unknown and could frequently be within a distance of tens of metres from a residential TV aerial.

A10.73 The uplink service could also originate from a neighbouring house as shown in Figure 10.22 below. In this scenario the mobile broadband uplink is in a fixed position. If necessary co-ordination is possible between the mobile broadband operator and the DTT operator. Co-ordination could be more difficult if the DTT and the last-mile broadband service are wanted in the same residential area.

Figure 10.22 Hole punching scenario last-mile broadband system uplink transmitter causing interference to DTT



Uplink interference from a mobile terminal

A10.74 Using the example of a 3G mobile phone it is possible to identify at what distance uplink interference could start to cause interference to a DTT receiver which is using rooftop aerials. The maximum specified transmit power of a handheld mobile phone in current 3GPP specifications is 21dBm. A 3G phone uses a power control mechanism to ensure that it does not use more power than is necessary and to limit the level of inter-system interference.

A10.75 The Aegis technical report concluded that the hole punching problem would be much greater at the edge of a main station DTT coverage area (where the received field strength is expected to be lower). In this situation it is believed possible that a mobile broadband/mobile communications service transmitting at maximum power could cause interference up to 300m away. The same calculations for the case of image channel interference (interferer is on a frequency nine channels above that the DTT receiver is tuned to) give separation distances of up to 110m.

A10.76 The Aegis report concludes that there is a real risk to the domestic reception of the existing DTT services by the use of mobile up-link services operating on adjacent and (to a lesser extent) image channel frequencies. It is therefore proposed that the actual statistical likelihood of interference, which takes into account the position of the mobile in the DTT service area, the power control mechanisms of the mobile and the transient nature of the moving mobile transmitter should be investigated (probably using Monte Carlo software).

A10.77 Unlike other UK spectrum awards, there is a long lead time for the nationwide availability of digital dividend spectrum (2012). It is important to note that advances in both cellular and mobile broadband technologies are planned within the timescale of award and the availability of the spectrum. The technical studies being done at international meetings, the resulting policy decisions and the political landscape should still be monitored against any decisions Ofcom makes on the potential use of the band for mobile uplink.

A10.78 The above analysis demonstrates that it is possible that mobile stations (handsets) which operate in transmit mode (uplink) within the DDR spectrum may cause some interference to DTT receivers which are located relatively close to the mobile stations. The exact level of interference will be dependent upon a number of factors including:

- the type of service;
- the orientation of interfering mobile station (being in line between the receive aerial and DTT transmitter will cause the maximum level of interference);
- relationship between the wanted and interfering channel (adjacent channels will cause higher levels of interference than image channel operation);
- the quality of the DTT receiver's adjacent and image channel rejection filters; and
- the remedial actions that can be taken by broadcast stations causing similar interference (location of the transmitter away from residential households, careful selection of suitable frequencies in arrears of specific concern or re-broadcasting of the DTT service from the BS site) are not applicable for mobile stations.

A10.79 This technical analysis therefore concludes that there is a risk that domestic reception of the existing DTT services could be affected by the use of up-link services operating on adjacent and (to a lesser extent) image channel frequencies and that measures should be considered to mitigate against this risk.

A10.80 In order to help Ofcom understand better the possible extent of any uplink interference ERA were commissioned by Ofcom to carry out a series of laboratory and field tests to assess how typical 3G and WiMAX uplink services may actually affect the reception of DTT services. This work was only completed by ERA in late November and so there has not been enough time to take the results into account in this analysis. A summary of the results are included in Annex 11 and the full report is being published on the Ofcom website alongside the consultation document.

A10.81 The initial results from the ERA tests appear to show that the uplink signals cause less interference to the reception of DTT services than the initial modelling suggests. These results need to be fully verified via further tests before they can be fully utilised. However, they do suggest that there may be fewer problems in using mobile uplinks in the cleared spectrum than as has been thought to date.

Programme Making and Special Events (PMSE)

A10.82 In most cases, co-channel operation of DVB–T and radio microphones within a DVB–T coverage area will cause unacceptable interference to radio microphones and vice-versa. However, indoor operation of radio microphones, for instance in theatres, may be feasible even if these operate on the same channel as a DTT service depending on building shielding loss and the location of the nearest DVB-T receiver. These cases may be evaluated on a site by site basis.

A10.83 Operation of radio microphones in the adjacent channel to that used by a DTT service will be possible in a lot of cases providing a guard band of the first 500 kHz of this channel is used. The necessary separation distances for SE PT 21 spectrum masks are longer than for the Chester spectrum mask, in particular if the DTT service originates from a low powered transmitter and the receivers have a high antenna gain (the value of the SE21 spectrum mask relates to the output power and not the E.R.P. of the DTT transmitter).

A10.84 In practice, use of the 2nd adjacent channel (n + 2) by radio microphones will be feasible in most cases. This applies to both indoor and outdoor operation of radio microphones. The necessary separation distances for SE PT 21 spectrum masks are again longer than for the Chester mask.

A10.85 The measurements of these protection ratio measurements were limited to professional DTT receivers. The immunity of domestic receivers, particularly for adjacent channel rejection, is not fully known. Therefore the frequency separation needed between the future wanted DTT channel and radio microphone operation may change slightly for domestic receivers.

Discussion of Constraints

A10.86 Section 3 of this consultation summarised the essential constraints that are expected to exist on the future use of the available UHF spectrum. These constraints are based upon the technical analysis discussed above and in the supporting technical reports that have been published alongside this consultation. The following text discusses the legal basis governing the international agreements and the technical background and rationale for the main conclusions outlined in Section 3 in more detail.

International constraints

A10.87 Signals from transmitters in the UK can cause interference to the reception of broadcasting services in other countries, and vice-versa. This is a particular issue for transmitters that operate at high-power, as the signals travel further, and for transmitters near a border with neighbouring countries.

A10.88 Terrestrial television broadcasting typically involves the use of a network of transmitters operating at high power, often located well above sea level on a high mast. Additional coverage is provided by a large number of relays operating at lower power, some of which are located in coastal areas.

A10.89 This 'high power, high tower' model of a broadcast network dates back many years, to the origins of broadcast network planning on a large scale in the decades following the Second World War. This was an era in which there were many fewer uses for spectrum than today. Networks were therefore generally designed to economise on infrastructure, rather than spectrum.

A10.90 The potential range of interference from a high power broadcast transmitter can be many times the range of reliable coverage, at least for small percentages of the time. For many transmitters in the UK this interference can extend at least to our nearest neighbours (France, Belgium, the Netherlands and Ireland), and even beyond. Services in those countries interact with their neighbours, and so on across Europe, creating a complex pattern of mutual interdependence.

A10.91 Digital terrestrial broadcasting will typically use high power transmitters much as analogue does now. The problem of international interference will not therefore be removed, though its details will alter with changes in the detailed technical parameters.

A10.92 In relation to analogue television, a fully co-ordinated spectrum plan was agreed for Europe at a conference held by the International Telecommunications Union (ITU) in Stockholm in 1961. This covered the use of VHF (Bands I and III) and UHF (Bands IV and V).

A10.93 The adoption of the Stockholm Plan by Europe was essential for the co-ordinated launch of analogue colour television services across Europe during the 1960s. In order to provide similar certainty for the switch from analogue to digital broadcasting, it was essential to establish a new international agreement on the use of frequencies across Europe.

The Radio Regulations

A10.94 The use of spectrum by one country has the potential to interfere harmfully with other countries' use of spectrum. The ITU, under the auspices of the UN, is responsible for the application of detailed rules about international use of spectrum, called the Radio Regulations. The Radio Regulations contain a Table of Frequency Allocations (the "Table") showing permitted uses for specified blocks of spectrum. The Table shows that in Region 1 (Europe, Africa and most of the Middle East) the frequencies being considered by the DDR (470 – 862 MHz) are allocated on a primary basis to the broadcasting service[50].

[50] The frequency band 790 MHz to 862 MHz is also allocated on a primary basis to the fixed service, defined in Article 1.20 as 'a radiocommunication service between specified fixed points'.

A10.95 Member states cannot assign a frequency to a station contrary to the allocation for that frequency in the Table, unless the station when using the assignment does not cause harmful interference to, and does not claim protection from harmful interference from, a station operating in accordance with the relevant allocation in the Table and the other provisions of the Radio Regulations[51].

A10.96 Assignments of spectrum to particular stations can be protected from harmful interference from stations in other member states by being entered into a register of assignments kept by the ITU (the "Register"). The normal procedure is that a member state notifies an assignment to the ITU; the ITU checks that it is in accordance with the relevant allocation in the Table, and checks whether the assignment would interfere with another assignment already registered, and if so whether the assignment has been coordinated with the country concerned; and if everything is in order, the assignment is entered into the Register. Competing notifications (ie a notification where the proposed use would cause harmful interference with the subject of another notification) are dealt with on a first-come, first-served basis.

RRC06 – The Geneva 06 agreement

A10.97 As stated above, competing notifications to the ITU for entry into the Register are generally resolved on a first-come, first-served basis. The exception is where an a priori frequency assignment plan is agreed. Digital terrestrial broadcasting is subject to such a plan.

A10.98 Some of the member states of the ITU assembled in May/June 2006 for the Regional Radio Conference, Geneva 2006[52]. This led to the adoption by those member states of an agreement for the planning of digital terrestrial broadcasting services in the frequency bands 174 – 230 MHz and 470 – 862 MHz (the "Geneva 2006 Agreement").

A10.99 The aim of the Geneva 2006 Agreement is to provide access to the spectrum for each signatory country for the introduction of digital broadcasting, on an equitable basis, and avoid the uncertainty of the “first-come, first-served” approach of the general notification procedure under the Radio Regulations. The planning approach has been traditionally adopted for the bands allocated to broadcasting as it is particularly suited to applications involving high-power transmissions (with the resulting interaction between countries) and where all countries are likely to have requirements for spectrum access.

A10.100 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', which forms part of the Geneva 2006 Agreement. The Digital Plan entries for the UHF Bands IV and V (470 – 862 MHz) assume the use of the DVB-T standard resulting in a frequency 'envelope' applicable to each assignment.

A10.101 The Geneva 2006 Agreement also contains other planning assumptions including characteristics of the receiving station, the percentage of time for which the

[51] Article 4.4 of the Radio Regulations

[52] The composition of the “region” for the purposes of the Geneva 2006 conference comprised about 120 countries from Europe, Africa and the Middle East; member states of North and South America, amongst others, did not take part in this Regional Radio Conference.

intended service is protected, and the propagation model (the methodology for calculating the level of signal at a distance from the transmitter, for specific percentages of the time). If the assignments are made in accordance with the relevant frequency envelope and other planning assumptions, and neighbouring countries do likewise, then there should not be any harmful interference issues between member states.

A10.102 Assignments to particular stations confer a priori rights to countries but the bringing into use of an assignment must be notified to the ITU (in accordance with Article 5 of the Geneva 2006 Agreement) if international protection is to be obtained for that assignment. However, because the assignments will have been made in accordance with the Geneva 2006 Agreement, there should not be any issues about competing notifications by other member states who were party to the Geneva 2006 Agreement[53].

A10.103 Any modifications to the Digital Plan, including changes to entries in the plan and new assignments, must be notified to the ITU in accordance with Article 4 of the Geneva 2006 Agreement. The ITU will determine whether co-ordination with other countries is required and if so, evidence of successful co-ordination will be required before the modification will be entered into the Digital Plan. In this way the Digital Plan will be continually evolving.

A10.104 The UK has also entered into a number of bilateral agreements with other member states which supplement the provisions of the Geneva 2006 Agreement, by specifying precisely how the assignments apply in relation to particular station sites. These agreements record specific details such as additional technical constraints on assignments (eg power limitations in certain directions), acceptance of increased levels of interference or other agreed modifications to the Digital Plan or the planning assumptions in specific cases. They were used during the RRC to provide an additional level of detailed planning that could not be undertaken in the RRC's planning process and helped ensure that the plan met the specific requirements of the countries concerned. They complete some of the co-ordination procedures that would otherwise have to be undertaken after the RRC.

A10.105 The Regional Radio Conference also took steps to allow member states some flexibility in the use of the frequencies being discussed. Some of the member states signed a Declaration under which they formally declared that their Digital Plan entries might be used for other broadcasting uses or other terrestrial applications besides broadcasting with characteristics that may be different from those appearing in the Digital Plan, and the signatories undertook that any such use would be protected from harmful interference to the levels defined in the Digital Plan. This is on condition that any such use must still conform to the 'envelope' of the relevant Digital Plan entry. The UK was a signatory to the Declaration, as were all of the UK's neighbours[54].

A10.106 If the spectrum is assigned for digital terrestrial broadcasting in accordance with the assignments the UK has been given in the Geneva 2006 Agreement's Digital Plan, then these assignments will be protected from harmful international interference. Note that to be in accordance with the Geneva 2006 Agreement's Digital Plan, the assignments must be for stations at the sites specified in the Digital Plan.

[53] See further Article 11 of the Radio Regulations.
[54] Ireland, France, Denmark, Germany, the Netherlands, Belgium and Norway (amongst others including all EU member states) all signed the Declaration.

A10.107 It is also important to note that if the spectrum is used for digital terrestrial broadcasting or another use requiring high-powered transmitters where the assignment is for stations at sites other than those specified in the Digital Plan, then, unless the new assignments can be successfully coordinated internationally, the user must make sure 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.

A10.108 If the spectrum is assigned for a non-broadcasting purpose, then under the Declaration this is permissible so long as the use does not breach the 'envelope' defined in the Digital Plan. However, if the non-broadcasting use is a two-way use that requires a return path (or 'uplink') it is important to note that there is a potential problem. The downlink would be protected between RRC member states in so far as it accords with the relevant 'envelope' in the Digital Plan.

A10.109 However, the uplink is not protected from harmful international interference. Uplinks are not covered by the Geneva 2006 Agreement. Because such use is not in accordance with the allocation for this frequency block in the Radio Regulations, and there is no provision for notifying mobile transmitting stations in the Geneva 2006 Agreement, it is not possible to obtain protection by registering an assignment for this use in the Register.

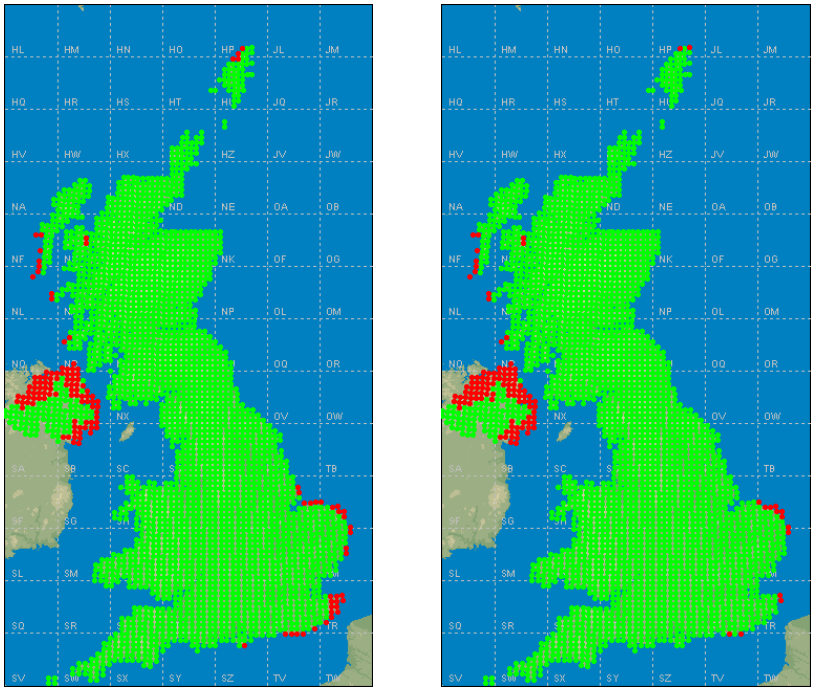
A10.110 In addition, the receiving station of a mobile uplink would only be protected from interference from other countries to a maximum height above ground level of 10m (the maximum height assumed for broadcasting reception). It may be possible to remedy this by changing the allocation for the UHF band at a World Radio Conference (in 2007 or 2010), but until/unless that happens it is crucial that this limitation on the use of the DDR spectrum is recognised.

A10.111 At each broadcasting station site in the Geneva Plan, the UK secured eight frequency assignments, with associated technical characteristics including transmitted power. Each one of these assignments is capable of carrying a digital television multiplex transmission. Six of these assignments 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.

A10.112 The migration of other countries to digital broadcasting is expected to cause certain levels of incoming interference in the UK – just as the UK's digital broadcasting will cause some interference abroad. Some of this incoming interference will affect spectrum in the digital dividend. The extent of this interference is expected to vary both by geography (the main effects will be near the UK's borders) and by frequency (though all channels are likely to be affected in some form).

A10.113 As part of this project, the expected impact of this interference on the usability of certain channels throughout the UK has been modelled. The maps reproduced below (see Aegis technical report for further details) simply provide one illustration of the way in which patterns of interference might vary across different channels. This assumes that these channels are to be used for the broadcasting of a DVB-H service in the UK using a dense network as discussed above. The red areas on the map show locations where reception of the DVB-H could be affected by incoming interference.

Figure 10.23 Example of areas where DVB-H reception in channels 32 and 33 may be limited due to harmful interference FROM other countries



Channel 32 Channel 33

Source: Aegis

A10.114 In conclusion 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 International Radio Regulations.

The European Union

A10.115 The European Union also has important powers and responsibilities in relation to management of the radio spectrum.

A10.116 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.

A10.117 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.

A10.118 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.

A10.119 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

A10.120 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.

A10.121 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.

A10.122 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, and this is reflected in its composition, which is generally at a more senior level than that of the RSC.

A10.123 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 are 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.

A10.124 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 Mobile Multimedia, 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 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 CEPT to study the issue.

A10.125 All the documents referred to above are available at http://rspg.groups.eu.int.

A10.126 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

A10.127 It is very important that new uses of spectrum do not cause 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.

A10.128 With the exception of channels 36, 38 and 69, the UHF band is currently predominantly used within the UK for the transmission of terrestrial television services. Services are transmitted from a network of 50 high power transmitter sites serving over 90% of UK households, and over 1,000 lower power relay transmitter sites. Altogether this network of transmitters provides coverage of the four principal analogue services (BBC1, BBC2, ITV & Channel 4/S4C) to 98.5% of UK households. There are also more limited network of transmitters carrying the Five service in analogue form, and the digital terrestrial transmitters, providing coverage of the six existing DTT multiplexes to around 73% of the UK population.

A10.129 At switchover, the analogue services will be switched off, and the coverage of the six digital multiplexes will be expanded to cover much more of the UK population. The constraints on spectrum are such that it is not possible for both analogue and digital services to be available near-universally at the same time. Analogue broadcasting is presently the means by which universal access is provided to the key public service channels free at point of delivery, but the Communications Act, and subsequent decisions taken by Ofcom and the government, provide that in future this role should be fulfilled by digital terrestrial broadcasting. However, it is not possible to achieve this without switching off the analogue signal – in other words, digital switchover.

A10.130 From digital switchover, the three digital multiplexes carrying public service channels will operate from a similar number of sites as used by analogue broadcasting now (at least 1,154). These PSB multiplexes should be available to the vast majority of UK households (98.5%). The three commercial multiplexes have decided to operate at higher power from their current 81 sites enabling them to cover around 90% of UK households.

A10.131 Given the greater efficiency of digital broadcasting, these digital multiplexes will require much less UHF spectrum than analogue broadcasting – while still greatly increasing the capacity and availability of services. Figure 10.24 provides summary information on the six multiplexes expected to operate at DSO.

Figure 10.24 Summary of the Six DTT Multiplexes

Name	Licensee	Status at DSO	Estimated coverage at DSO (UK households)
Mux 1	BBC	Public service multiplex	Regulatory requirement for 98.5%
Mux 2	Digital 3&4	Public service multiplex co-owned	Regulatory requirement for 98.5%

		by ITV, Channel 4, as function of holding public service licences	
Mux B	BBC	Public service multiplex	Regulatory requirement for 98.5%
Mux A	SDN	Commercial multiplex	Commercial decision - expected to be around 90%
Mux C	NGW	Commercial multiplex	Commercial decision – expected to be around 90%
Mux D	NGW	Commercial multiplex	Commercial decision – expected to be around 90%

A10.132 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 arise as a result of this expected pattern of usage and the need to protect viewers reception of these services.

Interleaved spectrum usage

A10.133 The multiplex operators will be operating six interleaved DTT networks within the retained spectrum (channels 21 to 30 and 41 to 62). 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 Website for further details).

A10.134 This means that there will be limited availability of spectrum within the interleaved spectrum with frequencies only being available in a limited number of locations, and with their use being severely constrained due to the need to protect the domestic reception of the six DTT multiplex services operating on the same channel (see discussion of co-channel interference above) in the same or adjacent region.

A10.135 For example the following extract from the current DTT band plan show that the six multiplexes currently make use of a wide range of frequency channels across the UK (note that this is the current plan and therefore also covers the cleared channels). At DSO, the plan in operation will be similar in form, but it will exclude the cleared channels.

Figure 10.25: Summary of the current DTT frequency assignments

Station	Mux 1	Mux 2	Mux A	Mux B	Mux C	Mux D
	Ch	Ch	Ch	Ch	Ch	Ch
Aberdare	28	32	23	26	29	33
Angus	68	66	59	62	56	65
Beacon Hill	52	61	58	54	56	64
Belmont	30	48	68	66	50	57
Bilsdale	34	21	31	24	27	42
Black Hill	41	47	44	51	55	65
Blaenplwyf	28	22	25	32	29	33
Bluebell Hill	59	62	60	45	42	39
Bressay	21	24	27	31	66	68
Brierley Hill	68	66	56	45	42	62

Bristol Ilchester Crescent	49	39	41	44	47	51
Bristol Kings Weston	22	25	28	32	30	34
Bromsgrove	49	48	55	59	65	67
Brougher Mtn	30	34	23	26	29	33
Caldbeck	25	23	26	39	45	42
Caradon Hill	34	31	48	21	24	27
Carmel	55	65	59	62	68	66
Chatton	40	50	43	46	47	51
Chesterfield	34	39	42	56	60	63
Craigkelly	33	29	23	26	42	39
Crystal Palace	25	22	32	28	29	34

A10.136 As a result, it is likely that the interleaved spectrum will be most suitable for additional broadcast type services, generally co-located at existing DTT sites, or low powered localised applications such as those used for programme making and special events (PMSE) services. Ofcom's analysis has shown that both of these types of service are compatible with the planned DTT services, providing that the following appropriate constraints are adopted:

A10.137 Interleaved broadcast services: Any new service operating within the interleaved spectrum would have to operate in such a way as to ensure that its signals did not affect adversely viewers reception of the six DTT multiplexes. This can happen if the new service is operating on the same frequency or on an adjacent or image channel as a DTT service in the same area.

A10.138 It is therefore essential that any new service proposing to operate within the interleaved spectrum is subject to careful planning taking into account the planning assumptions and tools used by the digital terrestrial television planners. Digital terrestrial television planning is carried out in the UK by the Joint Planning Project[55] (JPP).

A10.139 The JPP carries out the detailed frequency planning for digital switchover. The main parameters used are contained in a specially developed planning model called the UK planning model (UKPM). Further details are available from Ofcom on this model. Ofcom has commissioned a planning study from LS telcom which, using these parameters, has identified a series of compatible assignments based at 44 of the 50 main stations used by the DTT multiplex operators (see Annex 11 for a summary of the LS telcom work).

A10.140 These assignments would be suitable for the transmission of DVB-T services or other broadcast technologies which exhibit similar spectrum characteristics and operate within the power and location constraints identified by the LS telcom study. The exact location and characteristics of any assignments being considered within the DDR project are discussed further in Section 9 (Spectrum requirements and packaging).

A10.141 PMSE services: These services already operate within the UHF spectrum under a planning regime implemented by JFMG[56] under contract to Ofcom. The licences are

[55] The JPP is a group chaired by Ofcom comprising broadcast planners from the BBC, Arqiva and National Grid Wireless (both under contract to Ofcom) and the terrestrial broadcasters.
[56] 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.

mainly issued to operators to allow them to operate low power radio microphones and in-ear monitoring systems. Ofcom has commissioned a detailed study into the current usage patterns and spectrum demand of these services from Sagentia (see summary in Annex 11). The full report is available on the Ofcom website.

A10.142 This study has concluded that depending upon the outcome of the DDR process these services could continue to be operated on an interleaved basis within the interleaved 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.

Cleared spectrum usage

A10.143 Non-Broadcast channels:The digital switchover process will result in the clearance of fourteen UHF channels. As previously noted the DDR is also considering the future use of two additional channels. The first of these is channel 36 which is currently used for airport radar at Filton near Bristol. The other channel not being used for broadcasting is channel 69 which is currently being used by PMSE users across the UK. Channel 38 is 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.

A10.144 Details of the current use of channel 36 are available in Section 3 of the consultation document.

A10.145 The current international agreement covering use of channel 36 by the UK (the Geneva 06 Agreement) only covers use of this frequency for ground-based aeronautical radar (at a total of five widely-distributed sites). The UK therefore 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. Some clarity and certainty may be possible by the middle of 2007.

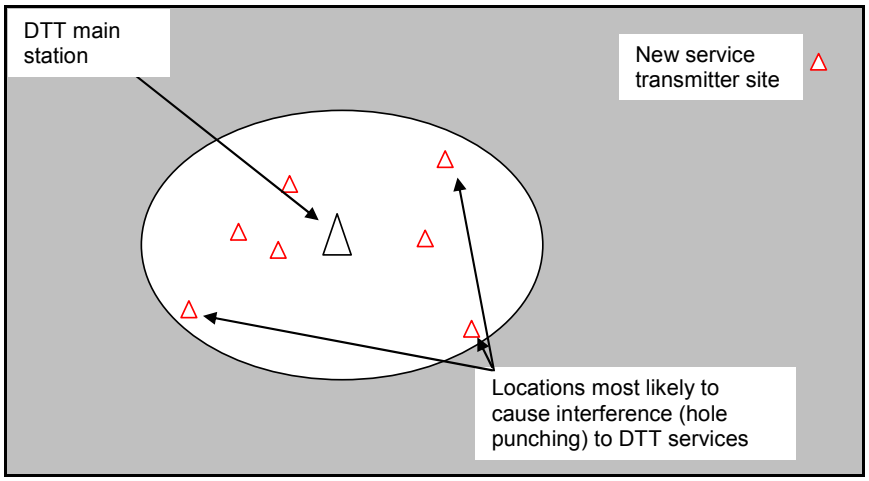
A10.146 Whilst no other services are licensed to operate on channel 36 in the UK, it is likely that there will be services operating on these frequencies in neighbouring countries which are expected to be utilising their Geneva 06 assignments. Any new services operating within the UK will have to ensure that they do not exceed the interference limits incorporated in the GE06 agreement (see discussion of international constraints above and Section 3).

A10.147 Any new services will also have to ensure that they provide adequate protection to DTT services being broadcast within the retained spectrum, 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:

A10.148 Protection of DTT services within the retained spectrum: As discussed above, 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. This issue is discussed in more detail above.

A10.149 The technical analysis concluded that hole punching generally only occurs in circumstances when the received signal strength from the interfering service is significantly higher than that of the DTT service at the DTT receiver. This can occur when the two services are transmitted from different locations or at different power levels. For instance hole punching can occur if the DTT service is transmitted from a high power main station and the interfering service is transmitted from a transmitter site (either from a fixed broadcast site or from a mobile handset transmitting an uplink 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 field strength. See Figure 10.26 for details.

Figure 10.26 Most likely locations causing hole punching to high power DTT reception



A10.150 The technical analysis has concluded that this interference could be minimised by the new service operator adopting a number of strategies. These strategies are summarised below and are discussed in more detail in the Aegis technical report:

- 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.

A10.151 In general any one of these techniques could help to enable fixed services being broadcast in adjacent or image channels to DTT services to operate without causing problems. However, it is likely 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 above. 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.

A10.152 It is important to note that Ofcom does not consider that this justifies a prohibition on the two-way mobile services (such as mobile communications using cellular

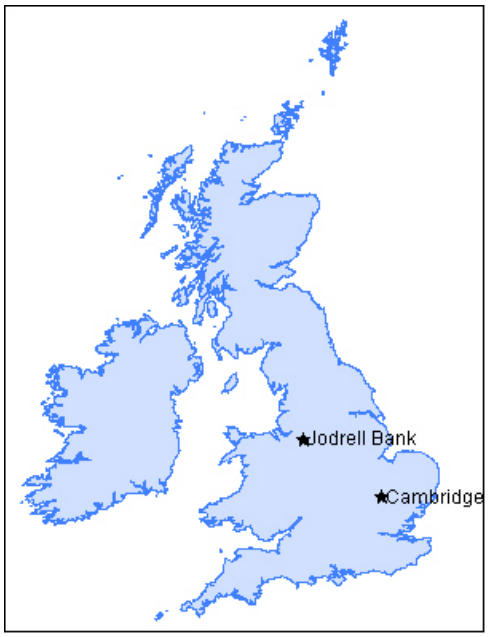
technology or broadband wireless services) from using the cleared spectrum. It may, for example, be feasible to use spectrum within the UHF band for the downlink element of a service, and spectrum in another band for the uplink. More generally, while it is important to be clear about the limits required to avoid harmful interference, it should be a matter for potential users to decide how these limits can be met.

A10.153 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 lay down 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 in sections 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 laid down in the Geneva 06 Agreement.

A10.154 Protection of Radio Astronomy Services using channel 38: The protection afforded to radio astronomy is detailed in Annex D of UK FAT (Frequency Allocation Table) and currently there are three radio astronomy sites (Jodrell Bank, Cambridge and Defford) listed in the annex for use of the channel. However, currently this band is used only at Jodrell Bank and Cambridge. If there are no future plans for use of this frequency at Defford then this site may be removed from the Annex D list in the future. Meanwhile the current level of protection afforded to all three sites will stay in place until the agreement is reached to change the Annex D listing.

A10.155 Existing broadcast use of the channels adjacent to channel 38 is already severely constrained by the need to minimise any interference to the radio astronomy use of channel 38. Similar restrictions would be required for other uses of these channels (that is channels 37 and 39) for any other services. The current requirement is that any emissions into channel 38 from services operating on the adjacent channel are kept below 12dB above the levels stated in ITU- R RA 769 at locations close to the radio astronomy locations.

Figure 10.27 Locations of current Radio astronomy use in the UK



Summary & conclusions

A10.156 Due to the varying nature of neighbouring countries' use of the UHF channels (arising from the pattern of assignments contained within the GE06 Agreement) the extent and locations of incoming interference will vary across different cleared channels.

A10.157 Due to the complex nature of the planned use of the interleaved spectrum by the six multiplex operators it is concluded that any spare capacity within the retained spectrum is most suitable for use by additional low power DTT services or low power PMSE services. Other potential uses will not be prohibited, but will need to operate within the relevant interference constraints, which may prove difficult.

A10.158 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) happens 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 radiated signal strength of the service does not exceed the following limits:

- ***Adjacent channel to DTT:*** Field strength not to be greater than 25dB above the received DTT field strength at the DTT receiver input; and

- ***Image channel to DTT:*** Field strength not to be greater than 34dB above the received DTT field strength at the DTT receiver input.

A10.159 The technical analysis has indicated that the use of mobile handsets and mobile broadband terminals transmitting an uplink signal within the cleared spectrum would have considerable difficulty in meeting the adjacent and image channel 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. Further work carried out by ERA has indicated that this problem may not be as serious as the initial modelling suggests, further work is required to validate this assessment.

A10.160 Any service operating on channels 37 and 39 will have to meet the following criteria in order to protect the use of the channel for radio astronomy. Any emissions into channel 38 from services operating on the adjacent channel must be kept below 12dB above the levels stated in ITU- R RA 769 at the radio astronomy locations shown in the map.

Annex 11

Summary of technical studies

A11.1 Ofcom commissioned four technical studies to inform the analysis of the potential uses for the digital dividend spectrum:

- National Grid Wireless (NGW) to study the use of the cleared spectrum for an additional DTT multiplex;
- LS telcom to study the use of the interleaved spectrum for a local DTT multiplex;
- Sagentia (previously Scientific Generics) to study the use of the interleaved spectrum for PMSE services; and
- ERA Technology to study interference to DTT reception from 3G and Wi-Max services in the adjacent and image (n+9, i.e. the interference effects on a service in one channel from a service 9 channels away) channels.

A11.2 A summary of each study and its main findings and conclusions is given below.

A11.3 Ofcom is also publishing alongside the above studies a report from an earlier study by Quotient Associates called "Supply and demand of spectrum for programme making and special events". This work was commissioned by Ofcom in 2005, it has not formed part of Ofcom's DDR considerations but it is felt that it will provide stakeholders with useful additional background analysis into the overall PMSE sector.

NGW Studies – Additional DTT Multiplex in Cleared Spectrum

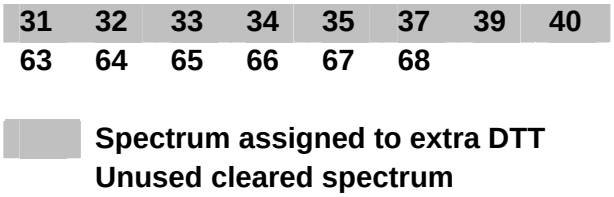
A11.4 Ofcom contracted NGW to carry out studies on the use of selected parts of the cleared spectrum band for an additional DTT multiplex as follows:

- Lower Cleared Spectrum Band (channels 31 to 35, 37, 39, 40);
- Upper Cleared Spectrum Band (channels 63 to 68); and
- Mixed Cleared Spectrum Band ie selected channels in lower and upper parts of the band (eg channels 31, 32, 33, 66, 67, 68).

NGW Study - Lower Cleared Spectrum Band

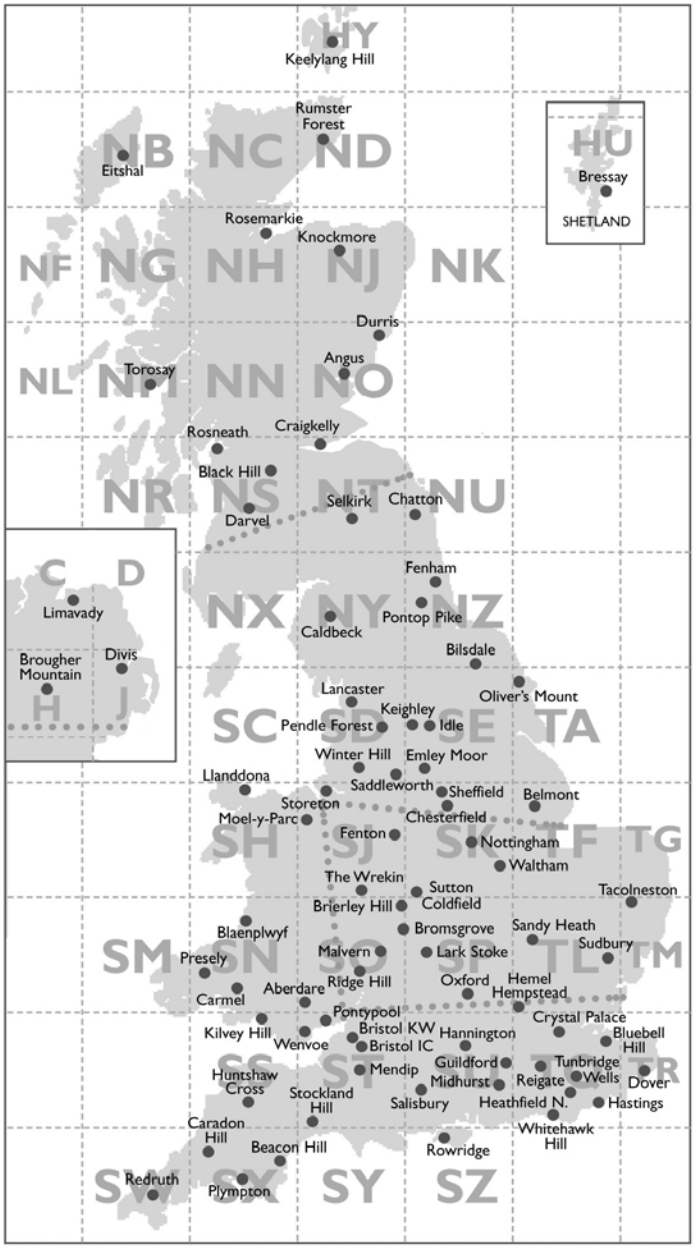
A11.5 NGW undertook a short, first pass study on the use of only the lower cleared spectrum band for an additional DTT multiplex (see Figure 11.1), based on a 64QAM 2/3 modulation.

Figure 11.1 Use of lower cleared spectrum band



A11.6 NGW allocated one channel from the lower cleared spectrum band to each of the largest 80 existing DTT stations (shown in Figure 11.2).

Figure 11.2: Location of the 80 largest existing DTT stations



A11.7 The allocation was done using the options of four, six or all eight channels in the lower band. NGW then predicted the coverage of this additional DTT multiplex for each option (assuming the use of an antenna pattern and an effective radiated power similar to the PSB multiplexes). The results are shown in Figure 11.3 below.

Figure 11.3 DTT coverage predictions for various cleared channel arrangements

Additional DTT Multiplex	Four channels 31-34	Six channels 31-34, 39-40	Eight channels 31-35, 37, 39-40
Coverage (80 DTT sites)	**93.7%**	**95.2%**	**96.4%**

A11.8 The six and eight channel options provide coverage which is comparable to the existing three PSB multiplexes (the coverage of PSB1 from 80 sites is predicted to be around 96%). The four channel option provides coverage which is a little better than the commercial multiplexes from the 80 sites. Note, NGW took account of incoming interference from Europe in the predictions, based on the GE06 plan.

A11.9 Television aerials are designed to receive a specific group of channels. There are six groups as shown in Figure 11.4 below.

Figure 11.4 Receive Aerial Groups

Aerial Group	**Receivable channels**	**Example station**
A	21-37	Crystal Palace
B	35-53	Sutton Coldfield
C/D	48-68	Winter Hill
E	35-68	Hannington
K	21-48	Sandy Heath (C5)
W	21-68	A few relays only

A11.10 For instance, in Manchester, the Winter Hill station transmits analogue television on channels 55, 59, 62 and 65. So Group C/D receive aerials are used in the area. Thus households in Manchester will need to change to a wideband (Group W) aerial (or install an additional aerial) to receive an additional DTT multiplex in the lower part of the band. This also applies to many other areas of the UK. Only households with Group A, K or W aerials will be able to receive the additional DTT multiplex without changing or adding a receive aerials.

A11.11 There will also be an impact upon the transmission infrastructure. At upper retained spectrum band stations (Channels 41 to 62), the antennas used to transmit the three PSB and three COM multiplexes may not be suitable for channels in the lower cleared spectrum band. So a separate transmission antenna may be needed for the additional DTT multiplex, which will be an extra cost. Note, there may not be enough room and/or load bearing capacity on the existing mast for another antenna. The requirement for another mast or extensive modifications to an existing mast will increase both the costs and difficulty of implementation significantly.

A11.12 There will be stringent filtering requirements for the use of channels 37 and 39 for an additional DTT multiplex close to radio-astronomy sites using channel 38.

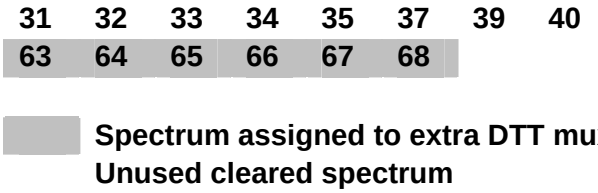
A11.13 The GE06 plan does not allocate channels in the lower cleared spectrum band to all UK stations. Consequently, to form a viable frequency plan for the additional DTT multiplex, NGW had to propose a number of channel changes. At present, any such changes are speculative and are subject to the successful negotiation of bilateral and multilateral co-ordination agreements with our European neighbours. The stations close to Ireland and on the south and east coasts of England cause the most interference to Europe, and thus are the most difficult to co-ordinate.

A11.14 With the lower band DTT option, there are at least six channels (63 to 68) that are unallocated, with possibly two (35, 37) or four (35, 37, 39, 40) further unallocated channels depending on the coverage requirements.

NGW Study - Upper Cleared Spectrum Band

A11.15 NGW was also contracted to carry out a short, first pass study on the use of only the upper cleared spectrum band for an additional DTT multiplex (see Figure A11.5), based on a 64QAM 2/3 modulation. NGW allocated one channel from the upper cleared spectrum band to each of the 80 existing DTT stations (assuming the use of an antenna pattern and an effective radiated power similar to the PSB multiplexes).

Figure 11.5 Use of upper cleared spectrum band



A11.16 NGW predicted the coverage of this additional DTT multiplex, from the 80 existing DTT stations, using all six channels in the upper cleared spectrum band, as 95.5%. This is comparable to the coverage of the existing three PSB multiplexes. NGW took account of incoming interference from Europe in the predictions, based on the GE06 plan.

A11.17 Only households with Group C/D (ch48-68) or W (ch21-68) aerials will be able to receive an additional DTT multiplex in the upper part of the band without changing or adding television aerials. For example, this excludes most households in London where Group A (ch21-37) aerials are commonly used.

A11.18 As with the lower cleared spectrum band there will also be an impact upon the transmission infrastructure. At lower retained spectrum band stations (Channels 21 to 30), the antennas used to transmit the three PSB and three COM multiplexes may not be suitable for channels in the upper cleared spectrum band. So a separate transmission antenna may be needed for the additional DTT multiplex, which will be an extra cost. Note, there may not be enough room and/or load bearing capacity on the existing mast for another antenna. The requirement for another mast or extensive modifications to an existing mast will increase both the costs and difficulty of implementation significantly.

A11.19 The GE06 plan does not allocate channels in the upper cleared spectrum band to all UK stations. So as with the discussion on the lower band above, NGW had to make a number of channel changes with the same international risks. Note that there is also a particular international issue in the upper cleared spectrum band with

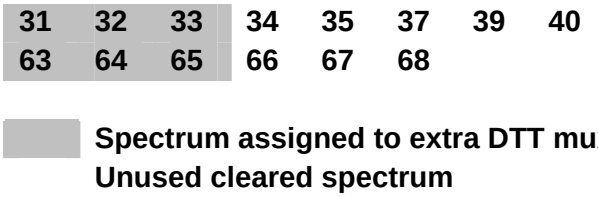
an existing bilateral agreement with France to avoid using channel 68 for high power in southern England.

A11.20 With the upper band option, eight channels (31 to 35, 37, 39, 40) remain unused.

Extrapolation of NGW Study[57] - Mixed Cleared Spectrum Band

A11.21 The lower or upper band only options both provide comparable, 94% to 96%, coverage for an additional DTT multiplex and both use a similar quantity (ie 6 to 10 channels) of cleared spectrum. However, the main drawback of these options is that many existing receive aerials and transmitter antennas will not be suitable due to the standard groupings of channels used in the DSO plan. These problems could be partially addressed by using a mixture of lower and upper band channels, for example, as shown in Figure A11.6.

Figure 11.6 Use of mixed cleared spectrum band



A11.22 The channels shown in Figure A11.6 were selected on the basis of:

- contiguity with the current retained spectrum;
- inclusion of the fourth Crystal Palace analogue conversion (channel 33); and
- avoidance of channel 68, as per a bilateral agreement, (French military use).

Nevertheless, other channel selections could be made to meet different criteria.

A11.23 No predictions of coverage have been made for this mixed band option. NGW indicated in its upper and lower band studies that the channel plan is largely determined by what can done for the stations in London, Kent and East Anglia. Beyond that, there is a reasonable degree of freedom as to which channels are used, with little to choose between the options available in terms of predicted coverage. Thus, it is expected that the use of any six cleared channels for the additional DTT multiplex could have coverage of around 95%. This is comparable to the existing PSB multiplexes.

A11.24 By using channels in both the upper and lower cleared spectrum bands, it should be feasible to plan the additional PSB multiplex so that more households can receive it on their existing television aerials. There will probably still be some stations where this is not possible, in particular those using cleared channel 40 such as Sutton Coldfield and Black Hill. However, there will be fewer households that need to change aerials than in the upper or lower band only options.

A11.25 Similarly, it may be possible to utilise more of the existing transmission infrastructure for the additional DTT multiplex, though this will vary from station to station.

[57] This work was carried out by Ofcom based on the NGW studies.

A11.26 International co-ordination may also be easier. A mixed band frequency plan should be able to use more existing GE06 allocations, which are already co-ordinated. However, there will still be some channel changes which will need agreement with our European neighbours.

A11.27 With this mixed band option, eight channels (34, 35, 37, 39, 40, 66, 67, 68) remain unused.

Summary of NGW Studies

A11.28 Figure 11.7 below summarises the options for using the cleared spectrum for an additional DTT multiplex, in addition there are other possible channel configurations for mixed band options. Each option has its advantages and drawbacks.

Figure 11.7 Summary of Options for Additional DTT Multiplex

Criterion	Lower Band Only	Upper Band Only	Mixed Band
Cleared channels used	Four to Eight channels 31-34, 35, 37, 39-40	Six channels 63-68	Six channels 31-33, 63-65
Predicted coverage (from 80 stations)	94% to 96%	95.5%	95%
Receive aerial group	Many aerials out of group	Many aerials out of group	Some aerials out of group
Transmission infrastructure	New antennas & masts may be required	New antennas & masts may be required	Use of existing antennas may be possible
International co-ordination	Required.	Required.	Partially Required.
Remaining digital dividend	Six to Ten channels 63-68; 35, 37, 39, 40	Eight channels 31-35, 37, 39, 40	Eight channels 34, 35, 37, 39, 40, 66-68

A11.29 Figure 11.8 below quantifies the stations in and out of the existing receive aerial group for each of the options.

Figure 11.8 Receive Aerial Group Issues

Option	In Aerial Group	Out of Aerial Group
Lower Band Only	50 stations including coverage of London, Birmingham, Glasgow, Southampton	30 stations including coverage of Manchester, Oxford, Bristol
Upper Band Only	27 stations including coverage of Manchester, Oxford, Bristol	53 stations including coverage of London, Birmingham, Glasgow, Southampton

Mixed Band	63 stations including coverage of London, Manchester, Southampton, Bristol	17 stations including coverage of Birmingham, Glasgow, Cardiff

LS telcom Study – Local DTT Multiplex in Interleaved Spectrum

A11.30 LS telcom carried out a study looking at the potential use of the interleaved spectrum for:

- a high capacity DTT multiplex (64QAM 2/3), eg for another commercial multiplex;
- a low capacity DTT multiplex (QPSK 2/3), eg for a local DTT multiplex; and
- both of the above.

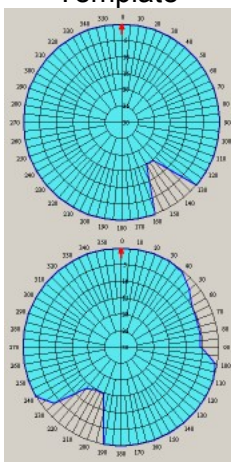
A11.31 The study took into account the need to protect the six DTT multiplexes (based on the v5.2 DSO frequency plan at the time), and the need to observe any international agreements governing the UK's use of this spectrum (based on the best information at the time, which was before the GE06 plan was agreed). As both the UK and GE06 plans have developed since the study was done, individual channel allocations and coverage predictions at some sites may no longer be up to date.

A11.32 In this section, interleaved spectrum refers to the technique whereby the same frequency is used to broadcast television services in many different parts of the country. The reuse distance for each frequency is determined by a combination of the transmitter power used, the minimum level of interference allowed to receive the services within the predicted coverage area and the terrain between the two transmitters. For instance the use of a frequency for a very high powered transmission from a tall mast would preclude the reuse of that frequency for several hundred kilometres, whereas the use of the same frequency for a low power transmission from a short mast would enable a much shorter reuse distance.

A11.33 14 of the 46 frequency channels currently used for broadcasting will be cleared following DSO. The remaining 32 retained channels will be used by the six existing DTT multiplexes on an interleaved basis. LS telcom investigated whether it was possible to accommodate one or two additional DTT multiplexes by reusing frequencies in the interleaved spectrum.

A11.34 LS telcom carried out a frequency search which looked at the interferers for each channel at each of the 50 main stations. The channels with the lower useable field strength were considered, and the best two channels (where available) were selected. A preference for channels in the local receive aerial group was specified. The protection of other transmitters determines the maximum power and the antenna template that can be used. Figure 11.9 below shows, as an example, the channels, powers and antenna template determined for the Sutton Coldfield (Birmingham) station.

Figure 11.9 Sutton Coldfield channels

Channel	ERP	Template
51	**1.3kW**	
29	**0.4kW**	

A11.35 For the 50 main stations, LS telcom found that:

- no frequencies were available at six main stations;
- one frequency was available at three main stations; and
- two frequencies were available at the remaining 41 main stations.

A11.36 The predicted coverage of a high capacity and a low capacity network using the frequencies found above is given in the figure below. Cases 1 and 2 refer to how the best channels are allocated at each site.

Figure 11.10

Case	Network	Channel Allocation	UK Coverage
1	64QAM (high capacity)	Best 44 channels	72%
	QPSK (low capacity)	Remaining 41 channels	67%
2	QPSK (low capacity)	Best 44 channels	86%
	64QAM (high capacity)	Remaining 41 channels	50%

A11.37 With regards to receive aerials, 29 of the best 44 channels are in the aerial group, thus 15 channels are out of group. 16 of the remaining 41 channels are in the aerial group, thus 25 channels are out of group.

A11.38 There are various caveats associated with the coverage predictions as follows:

- antenna templates were used in the predictions, incorporating the necessary restrictions for protecting other transmitters from interference. In reality, a

practical antenna pattern will be worse than a theoretical template, so coverage will also be worse;

- the universe in which the additional high and low capacity multiplexes were planned assumed that the v5.2 DSO frequency plan was used for the existing three PSB and three commercial multiplexes; and assumed a particular European interference scenario (before the GE06 plan was agreed) which is probably now somewhat optimistic; and

- a 3dB increase in usable field strength was allowed in order to reasonably find frequencies for the extra high and low capacity multiplexes. Thus, there may be an impact on the coverage of the existing three PSB and three commercial multiplexes, which will need to be mitigated.

Sagentia Study – PMSE services in Interleaved Spectrum

A11.39 Sagentia Ltd (previously called Scientific Generics) was commissioned by Ofcom to investigate:

- the current demands on the UHF spectrum by Programme Making and Special Events (PMSE) users;

- how this demand is likely to change post DSO; and

- the corresponding spectral requirements for PMSE equipment, such as radio microphones, in the future.

A11.40 PMSE currently uses all the UHF broadcast spectrum (Channel 21-68) where it is not used for TV broadcast, radar (Channel 36) or radio astronomy (Channel 38). An adjacent band, channel 69, is reserved for exclusive PMSE use. PMSE-related equipment licensed and used in the UHF broadcast spectrum includes:

- audio links such as hand-held and body-worn radio microphones and in-ear monitors (IEMs);

- talkback (these service links are also known as wireless intercom);

- programme links; and

- data links.

A11.41 To understand the spectral requirement for PMSE equipment following switchover Sagentia adopted the following approach:

A11.42 Segmenting the JFMG database: JFMG is the company that manages the PMSE licences (under contract to Ofcom). Its licence database for 2000-2005 was segmented into categories representing different types of PMSE usage. The derived usage types are:

- ***Background Use*** - ”Small scale” commercial and social use. Mainly operating in Ch 69 (and some channel 67 and 68). Commercial users are typically small regional theatres, AGM sites and race courses. Social users include schools, churches, village fetes and amateur theatre productions.

- ***Geographic Peaks -*** Long term use within fixed sites. Typically multi-equipment, multi-channel users. Example users include: West End Theatres, major broadcasters such as the BBC, major conference sites such as the NEC in Birmingham.

- ***Special Events -*** Short term, large events. These can be "one-off" or touring activities, ie:

  - "One-off" events (eg the Live 8 concert held in Hyde Park, WW2 memorial event)

  - PMSE use over multiple sites by a touring company (eg pop and rock band tours, touring theatre productions, etc).

A11.43 PMSE demand growth: Modelling demand for equipment, ie growth in organisations needing PMSE spectrum and equipment take-up prior to switchover. Modelling took into account the current demand for PMSE for different usage types. The technology issues for equipment and the potential impact on spectral efficiency, following DSO, was also considered.

A11.44 Post-DSO spectral requirements: Estimation of post-DSO PMSE use in 2012 for three migration scenarios requiring different spectrum use. The migration scenarios considered are:

- **Scenario 1:** Post-DSO, clearing all DDR channels, including Channel 69, of use. Allowing PMSE use only in the post DSO interleaved spectrum;

- **Scenario 2:** Post-DSO, clearing all DDR spectrum, except Channel 69, of use. Allowing PMSE use only in the post DSO interleaved spectrum; and

- **Scenario 3:** Post-DSO, clearing channels 31-40 of use. Allowing PMSE use in new interleaved spectrum in channels 63-68 as well as in the post DSO interleaved spectrum (assuming that secondary use is possible).

A11.45 The following figure indicates:

- potential percentage of equipment which will become obsolete after DSO, within each usage type, for each of the three scenarios modelled;

- corresponding estimates of the cost of the obsolete equipment (guideline figures only); and

- mechanisms for spectral efficiency improvement possible for each of the three scenarios considered.

Figure 11.11 Summary of projected impact of three scenarios

Usage Category	Scenario 1		Scenario 2		Scenario 3	
	Obsolete Equipment	Spectral efficiency Improvement	Obsolete Equipment	Spectral efficiency Improvement	Obsolete Equipment	Spectral efficiency Improvement
Special Event - Touring	70% £0.3m	Logistics	40%* £0.2m	Logistics	6% £0.025m	
Special Event - One-off	70% £2.5m	Logistics	40% £1.5m	Logistics	6% £0.22m	
Geographic Peaks	70% £7m	Technology	40%* £4m	Technology	6% £0.6m	
Background Social	95% £10m					
Background Commercial	95% £10m					

A11.46 Sagentia's key conclusions in the study for radio microphones were:

- there is adequate spectrum for radio microphones, but current use is very inefficient. Whilst this situation is starting to improve DSO will inject an impulse into the process and will create a need for better management;
- the current limitations of microphones make co-ordination between many co-sited users difficult, particularly at a special event, where time and equipment are limited. Scientifics Generics regard the need for better co-ordination as the major issue and not necessarily the amount of available spectrum. Better analogue and digital microphones can make this co-ordination easier;
- the estimate of Shared (ie Ch 69) usage is that there is adequate capacity for the foreseeable future for "nomadic" use (ie use by freelance sound recordists, news gatherers and equipment rental organisations operating over a wide geographic area);
- current Shared (ie Ch 69) users operating within fixed sites require better spectral efficiency in the near future to continue to operate within one channel. There is evidence of slow progression from Shared into interleaved (ie co-ordinated) spectrum; and
- Sagentia believe there is significant unlicensed use of channels 67 and 68, which will be difficult to move into new spectrum.

A11.47 Their key conclusions in the study for talkback were:

- most talkbacks operate in the spectrum to be cleared. Most of the remaining equipment operates in channels 21 and 22. Both these channels may be used for TV transmission after DSO; and
- spectral efficiency of talkbacks seems poor; moving to 200kHz channels improves sound quality, but so can digitisation at much greater spectral efficiency. It seems that the "low cost of spectrum" is acting to reduce spectral efficiency in this case.

A11.48 Their key conclusions in the study for the licence structure were:

- the current licence pricing structure does not support desired behaviour, for example:
  - talkback in 200kHz channels is at the same cost as 25kHz channels;
  - the is no premium pricing scheme for the national channel 69 licence; and
  - there is no differential pricing scheme according to the level of interference tolerated (ie "business critical" uses such as microphones at a live TV broadcast justifies greater protection than a talkback at the same site).

- licence pricing should discourage "contingency purchasing" (estimated to account for 10% of co-ordinated assignments) and should actively encourage higher spectral efficiency. An exponential model could be applied. For example:
  - pricing that requires a user to take up 12 mics/TV channel (eg £20/mic in the first channel);
  - opening up a second TV channel requires purchase of (say) 16 mics worth of assignments in the original channel; and
  - greater than 16 assignments in 1 channel comes free.
- current pricing for access to PMSE spectrum seems to be appropriate for the service offered, but the resources applied to provide that service seem excessive (for example, when compared to 3G spectrum cost, where a mobile network operator would expect to invest of the order of £20/subscriber/year).

A11.49 Finally, Sagentia's key conclusions in the study for industry were:

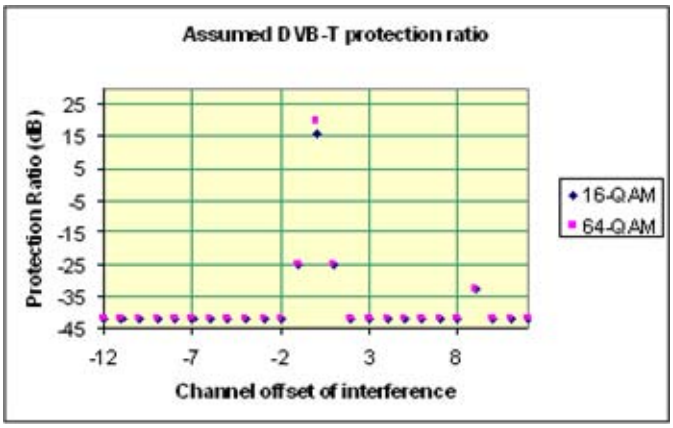
- UK manufacturers stand to benefit from the spectrum "squeeze" as they will be able to produce new equipment. Large manufacturers (ie volume manufacturers) are likely to ignore the small market for the premium products required; and
- the industry needs to adopt a more understandable mapping from the microphone setting (group, channel to the frequency on the licence to enable more accurate frequency selection by the user.

ERA Study – Adjacent & Image (N+9) Channel Interference to DTT Reception

A11.50 The potential uses of the cleared spectrum are wide ranging and include mobile broadband (Wi-Max) and mobile communications (for example 3G and systems beyond IMT-2000).

A11.51 ERA Technology was contracted by Ofcom to investigate the potential for interference to DTT receivers by services operating on adjacent and image (N+9) channels from 3G and Wi-Max transmitters, based on the assumed DVB-T protection ratio shown in Figure 11.12 below.

Figure 11.12 DVB-T protection ratio as a function of channel separation



A11.52 Within the cleared spectrum, new users of channels 31, 40, and 63 have the potential to cause adjacent channel interference to DTT services being broadcast in the interleaved spectrum assigned to the six DTT multiplexes (i.e. channels 30, 41 and 62). New users who operate using image channels (i.e. those at n+9) to those used by a DTT channel also have the potential to cause interference to the reception of that DTT service, this applies to all of the cleared channels with the exception of channel 40.

A11.53 The technical work carried out by Aegis raised a specific concern that uplink services (from WiMAX and cellular operators) operating on adjacent and image channels may cause specific interference problems due to the fact that they originate from a mobile device and do not in general enable the operator to mitigate any interference being caused by techniques that would be suitable for fixed installations.

A11.54 ERA Technology was therefore asked to:

- investigate adjacent and image channel interference to typical DTT receivers;
- simulate a 3G and Wi-Max uplink system transmitting on the channels to be released post digital switchover and to see if it causes interference to DTT receiver/s on the adjacent channel and nine channels below;
- determine the protection levels required to protect the DTT receiver/s to adjacent and image channels below by testing in a typical laboratory environment;
- simulate a real life environment with a fixed television-receiving antenna being interfered with by simulated 3G/WiMax mobile on the DTT frequencies; and
- determine the minimum distance a mobile transmitter (3G or Wi-Max) has to be before it causes interference to a DTT receiver.

Conducted Laboratory Measurements

A11.55 Six DTT receivers were tested by ERA for their susceptibility to adjacent and image channel interference. The results for image channel performance showed that there was a large variation between receivers; possibly due to their IF (Intermediate Frequency) filter characteristics.

A11.56 Four of the test receivers did not show any significant susceptibility to image channel interference from both 3G and WiMAX signals. One test receiver performed significantly worse than the others for rejecting the image channel. The difference between this (recorded as receiver 1) and one of the four (receiver 6) is shown in the attached graphs (Figure 11.13 & 11.14).

Figure 11.13 Receiver 1 adjacent and image channel performance (from 3G)

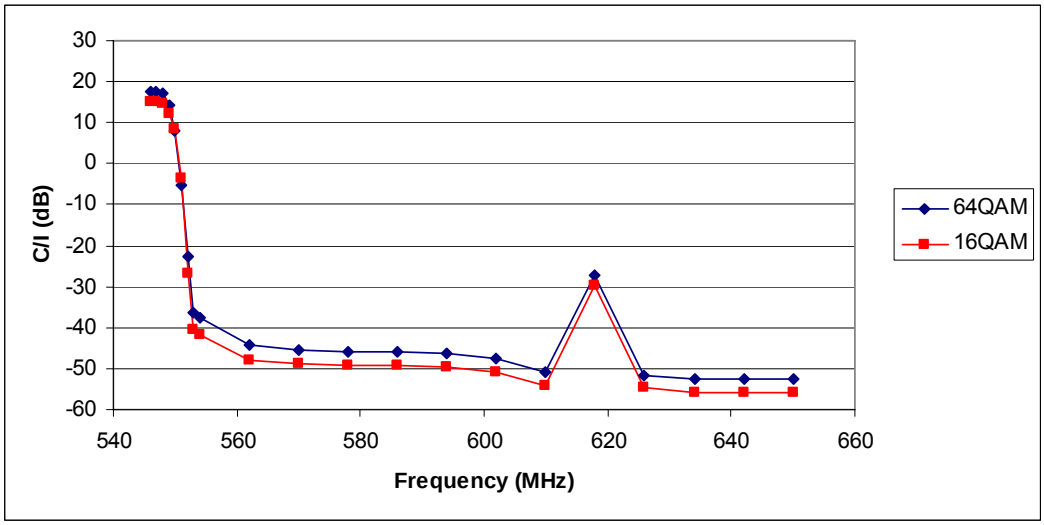
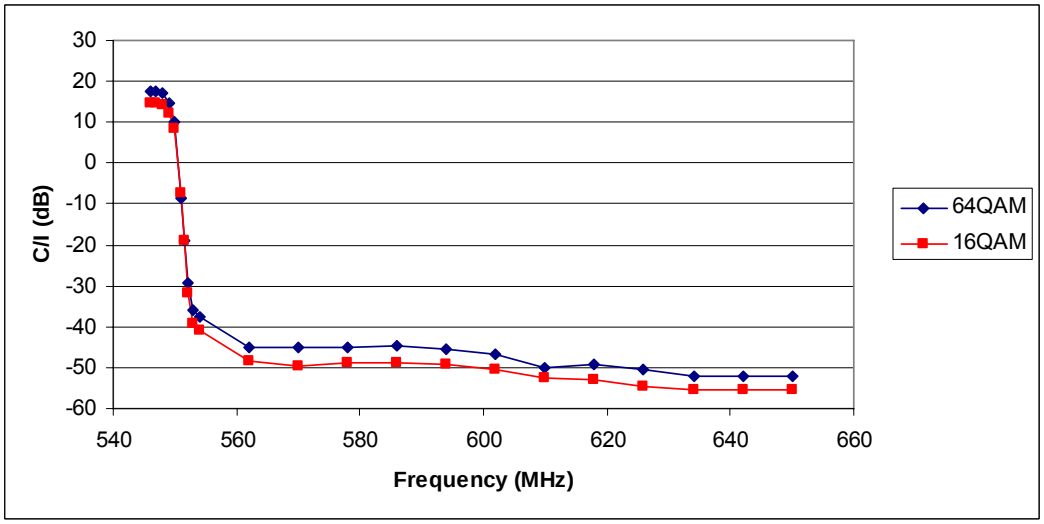


Figure 11.14 Receiver 6 adjacent and image channel performance (from 3G)



A11.57 The C/I[58] protection ratios for 3G and WiMAX adjacent channel interference were measured for six DVB-T receivers. The figure below shows the average adjacent channel interference for all six receivers, at three guard bands of 0.4 MHz, 1 MHz and 2 MHz (separation defined as being between the -3dB points on the transmitted spectra). These tests showed a variation in the protection ratio of the receivers of 4dB (3G) and 8dB (WiMAX) for adjacent channel and 23db (3G) and 18dB (WiMAX) for image channel.

[58] Carrier/ Interference ratio, normally expressed using dBs

Figure 11.15 Average C/I protection ratios for 3G and WiMAX adjacent channel interference to six DVB-T receivers

Interferer	Modulation	C/I (dB) with 0.4 MHz guard separation	C/I (dB) with 1 MHz guard separation	C/I (dB) with 2 MHz guard separation
3G	64QAM	-28	-35	-38
	16QAM	-32	-39	-42
WiMAX	64QAM	-27	-31	-32
	16QAM	-31	-35	-36

Radiated Measurements

A11.58 ERA then carried out some outdoor field measurements using the worst performing receiver. This simulated a typical scenario whereby a DTT receiver is to receive the wanted (DTT) service via a roof top aerial (located at 8.5 above ground). The aerial is set at horizontal polarisation pointing at the DTT transmitter. The interfering signal is transmitted from an aerial 1.5m above ground. ERA then measured the power level at which the interfering signal caused the DTT service to be lost. This was measured at various distances from the DTT aerial. These measurements are summarised in the two graphs below.

Figure 11.16 Measured EIRP as a function of distance for 3G and WiMAX adjacent channel interference to a DVB-T signal with a received electric field strength of 54 dBuV/m using a 1 MHz guard band

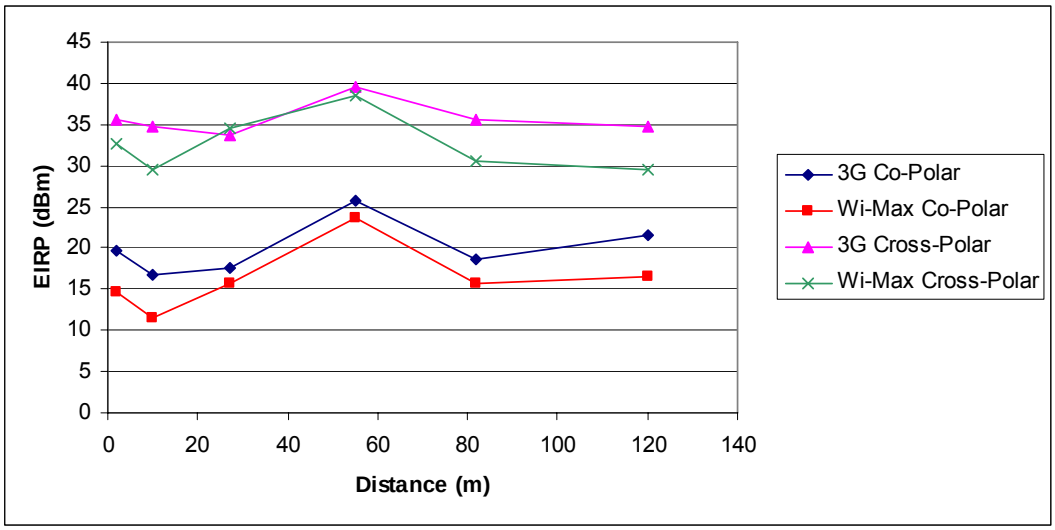
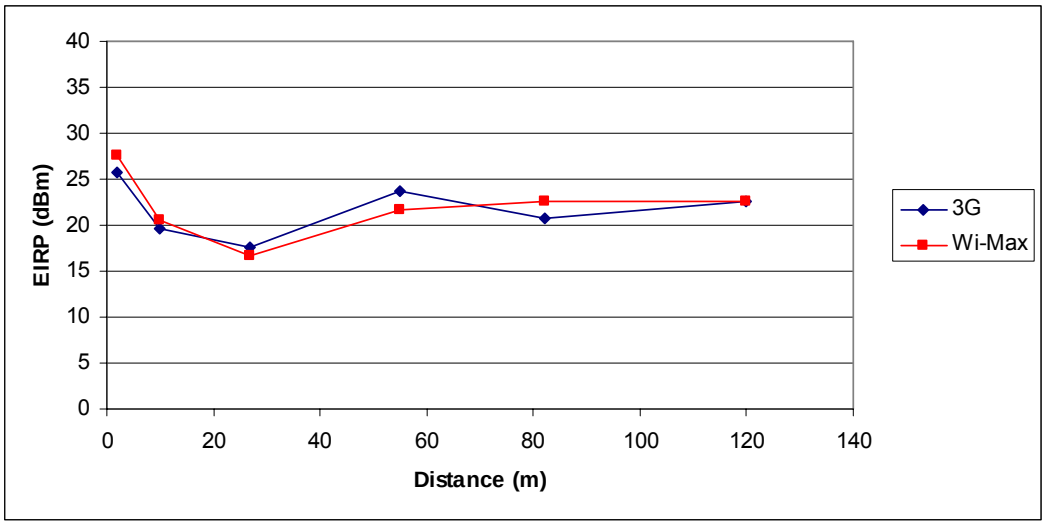


Figure 11.17 Measured EIRP as a function of distance for 3G and WiMAX N+9 channel interference co-polar to a DVB-T signal with a received electric field strength of 54 dBuV/m using a digital antenna



A11.59 When the digital TV antenna was replaced by an analogue TV antenna the measured results were very similar, indicating a very similar antenna pattern and gain profile.

A11.60 ERA also calculated what impact the use of a portable DTT domestic aerial would have on these figures. They concluded that this would be more susceptible to interference from a 3G/WiMAX interferer by an additional 7dB when compared to the outdoor digital or analogue TV antenna.

A11.61 The adjacent channel test shows that the if the services operate on different polarisations (eg DTT horizontal and 3G/WiMAX vertical) the worst case locations (12m & 82m) are above the maximum level that 3G and WiMAX transmitters would be expected to operate at. However, if the services were co-polar or if a portable set top aerial were used some interference may be expected.

Conclusions

A11.62 The results from the laboratory tests showed that there was a large variation in the performance of the six tested receivers.

A11.63 One test receiver performed significantly worse than the others for rejecting on the image (N+9) channel. Four of the test receivers did not show any significant susceptibility to image channel interference from both 3G and WiMAX signals.

A11.64 For the radiated measurements similar performance levels were observed for the digital and analogue antenna used in the radiated measurements. However, a portable digital TV antenna was calculated to be more susceptible (by around 7dB) to interference from a 3G/WiMAX when compared to the outdoor digital or analogue TV antenna.

A11.65 The radiated measurement results using both a digital and an analogue antenna indicate that with a 1MHz guard band to the adjacent channel and on the image (N+9) channel, the 3G or WiMAX mobile transmitting at its maximum power (at 21 dBm) is very unlikely to cause interference to the worst DTT receiver selected when the transmissions and aerial have cross-polar alignment.

A11.66 However when the transmissions and DTT aerial have co-polar alignment to the interferer, the results indicate that with a 1MHz guard band to the adjacent channel and on the N+9 channel that the 3G or WiMAX mobile transmitting at its maximum power may cause interference to the worst DTT receiver.

A11.67 To investigate the actual statistical likelihood of interference, which takes into account the position of the mobile in the DTT service area, the power control mechanisms of the mobile and the transient nature of the moving mobile transmitter, this should be modelled with Monte Carlo software. It is important to note that, both 3G and WiMAX mobile transmittesr are expected to use a power control mechanism to ensure that they do not use more power than is necessary and to limit the level of inter-system interference. The 3G and WiMAX mobile transmitter will only use its maximum transmit power when it is at the edge of its service area.

Annex 12

Terms of reference for the consultancy study - January 2006

Section 1 Introduction

A12.1 Ofcom announced on 17 November 2005 the beginning of its Digital Dividend Review ("DDR") – the project which will examine the options arising from the release of spectrum afforded by the digital switchover programme.

A12.2 The available spectrum includes the spectrum released by analogue switch off - the UHF spectrum in bands IV and V (470-862MHz) with the exception of the spectrum reserved for the 6 DTT multiplexes.

A12.3 The potential future uses of this spectrum are wide ranging and include: mobile broadband, mobile communications (for example, 3G and systems beyond IMT-2000), private mobile radio, further terrestrial digital television services (including standard definition television, high definition television and local digital TV), mobile digital multimedia (including mobile television), and Programme Making and Special Events ("PMSE"). This is not an exhaustive list nor does it indicate prior preference.

A12.4 With the launch of the DDR Ofcom has announced that amongst the key issues it will consider are the:

- potential uses of the available spectrum;
- technical limits on spectrum use to prevent potential interference;
- options for packaging frequencies to give maximum flexibility to the market; and
- options for the design of an efficient award/allocation process which aims to maximise the value of the available spectrum to society over time.

A12.5 As part of the DDR, Ofcom will be developing its policy on the award of this spectrum. In order to assist its policy development Ofcom is commissioning Analysys Consulting (leading a consortium including DotEcon, Aegis and Mason) to undertake a study to further its understanding of the available spectrum and its possible uses based on detailed market, technical and economic analysis.

A12.6 The market, technical and economic analysis will take into account the views from people and organisations with an interest in the use of this spectrum.

A12.7 This work by consultants will help to inform Ofcom's own policy development, which will result in the publication of a consultation document by Ofcom expected to be before the end of 2006.

A12.8 As with all spectrum awards, Ofcom's policy is to favour the use of market mechanisms to award this spectrum via a technology and usage neutral auction that maximises flexibility for the market. This approach is supported by the Government, as set out in the Secretary of State for Culture, Media and Sport's speech on 15 September 2005 confirming the timetable for DSO. It is also in

accordance with the European Commission communication of spectrum policy priorities for DSO, published on 29 September 2005.

Section 2 Terms of reference

Objectives of the study

A12.9 The overall objectives of this study are to:

12.9.1 Improve the understanding of the available spectrum and its uses from a market, technical and economic perspective. This will involve a structured process of information exchange between market participants, the consultants and Ofcom.

12.9.2 Consider a framework for the release of this resource to the market in a way that is likely to maximise benefits to society over time.

Market, technical and economic analysis

A12.10 The key objectives of this analysis are to:

12.10.1 Identify key potential uses and end user demand for this spectrum ("market analysis");

12.10.2 Identify the technical limits on the spectrum use ("technical analysis"); and

12.10.3 Identify the incremental economic value (producer and consumer surplus) generated from the different uses of the released spectrum ("economic analysis").

A12.11 The market analysis will seek to enlarge Ofcom's understanding of the commercial prospects and willingness to pay for spectrum for different uses. This will include building business case models for different spectrum uses and an assessment of how these business cases may vary dependent upon the use of different spectrum bands.

A12.12 This analysis is not intended to determine the optimal use of the spectrum, but to help Ofcom package the available spectrum in a way that gives the market maximum flexibility to meet likely demand. It is Ofcom's general policy to leave decisions on how spectrum is used, and by whom, to the market, as far as possible.

A12.13 The study will also include a detailed technical analysis which will assess the feasible uses of the UHF spectrum (taking account of international constraints resulting from Regional Radio Conference 2006) and of other potentially substitutable spectrum bands. In particular the technical analysis will include:

12.13.1 An assessment of how different uses can be combined within the available spectrum.

12.13.2 An assessment of the substitutability, from a technical perspective, of different spectrum bands. This will inform an assessment of the market implications of using different spectrum bands to provide the same service.

A12.14 The outputs of the market and the technical analysis will be combined to identify different possible combinations of uses of the band. This information is required to design an award process which allows an efficient outcome to be arrived at (highest value uses and users).

A12.15 The final step is to identify the incremental consumer and producer surplus generated from the released spectrum under the assumed demand and supply scenarios, taking account of whether other spectrum blocks are also used to provide the same services. This helps to inform the assessment of the benefits to the economy and society which may be generated from the use of this spectrum.

Assessment of optimal approach using market mechanisms

A12.16 Noting that Ofcom's policy is to favour the use of market mechanisms to award spectrum this study will provide advice on the market mechanism which could best be used to achieve an efficient allocation of this spectrum to highest value uses and users.

A12.17 This work stream involves building upon the work completed in the market, technical and economic analysis to take into account the likely future uses of this band, the types of organisations which may be bidding for spectrum, and the nature / pattern of their spectrum demands, in order to arrive at an assessment of the optimal approach for the award of this spectrum using market mechanisms.

A12.18 This assessment will include consideration of: competition issues, the award process (suitability of auctions and where relevant the appropriateness of different auction formats, including, for example, consideration of overlay auctions), licence terms, award timing and spectrum packaging.

Market and regulatory failures and potential forms of intervention

A12.19 Taking as a starting point the optimal market mechanism identified above, the study will also consider the relevance of any issues that may suggest a deviation from this approach.

A12.20 This aspect of the study will include the assessment of the strength of evidence for possible market failures, research into the different forms of intervention, including the potential for intervention to lead to regulatory failure, and assessment of the treatment of social and public values. This will be informed by the results of the market, technical and economic analysis.

Stakeholder interaction

A12.21 The study will involve significant engagement with stakeholders to develop a thorough understanding of possible future uses of this spectrum, the technical requirements of these uses and their market potential.

A12.22 The stakeholder interaction, alongside further independent research, will result in an assessment of the likely future uses of the available spectrum. These are the uses which will be considered in the market, technical and economic analysis.

Timing and deliverables

A12.23 It is anticipated that the study will provide interim results in the first half of 2006, with delivery of the final report to Ofcom in the second half of 2006.

A12.24 This work will help inform Ofcom's policy development, which should result in the publication of a consultation document expected by the end of 2006.

Section 3 Next steps

A12.25 It is Ofcom's objective that the study should be conducted on the basis of the best possible information available and should consider all the relevant issues. Ofcom is therefore keen for stakeholders to contribute to the study.

A12.26 The relevant point of contact for this consultancy study at Ofcom is:

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A12.27 The relevant points of contacts for this consultancy study at Analysys Consulting are:

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A12.28 The relevant point of contact for the Digital Dividend Review as a whole at Ofcom is:

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Annex 13

Glossary

2G Second generation of mobile telephony systems using digital encoding. 2G networks support voice, low speed data communications, and short messaging services

3G Third generation of mobile systems. Provide high-speed data transmission and supporting multimedia applications such as full-motion video, video-conferencing and Internet access

ACI Adjacent Channel interference. Interference caused by users in adjacent channels

AIP Administered Incentive Pricing. the charging of fees for the holding of spectrum that reflect the opportunity cost of the holding of that spectrum

Allotment Use of a radio frequency or radio frequency channel. Entry of a designated frequency channel in an agreed plan, adopted by a competent conference, for use by one or more administrations for a terrestrial or space radiocommunication service in one or more identified countries or geographical areas and under specified conditions

Assignment Use of a radio frequency or radio frequency channel. Authorisation given by an administration for a radio station to use a radio frequency or radio frequency channel under specified conditions

Bandwidth Physical characteristic of a telecommunications system that indicates the speed at which information can be transferred. In analogue systems, it is measured in cycles per second (Hertz) and in digital systems in binary bits per second (Bit/s)

Base station A radio transmitter and receiver installed by an operator, usually at a specific location, to provide a communications service, typically used in mobile telecommunications

BBC British Broadcasting Corporation

Bit-rates The rate at which digital information is carried within a specified communication channel

Broadband A service or connection generally defined as being "always on" and providing a bandwidth greater than 128kbit/s

BWA Broadband Wireless Access

CAA Civil Aviation Authority

CDMA Code division multiple access.

CEPT European Conference of Postal and Telecommunications Administrations

Channel (spectrum) A spectrum channel is a band of frequencies into which the spectrum has been divided eg channel 21 encompasses the band of frequencies from 470 MHz to 478 MHz, channel 22 is 478 MHz to 486MHz and so on

Channel (TV) A television station eg BBC1, ITV1, Channel 4, five etc

C/I Carrier/Interference

Cleared Spectrum Spectrum that will be available on a UK-wide basis following DSO

Co-Channel Interference Interference caused by other users of the same channel; This can affect receivers hundreds of kilometres away from sources of interference as their circuit is tuned to the same frequency as the interference

Co-Location The location of equipment such as a broadcasting mast in the same location as another operator

DAB Digital Audio Broadcasting

dB Decibels

DDR Digital Dividend Review

DECT Digital Enhanced Cordless Telecommunications, a technology standard for short range wireless communication

Digital Dividend, The The available UHF spectrum. The cleared, the potentially cleared and the interleaved spectrum

DMB Digital Multimedia Broadcasting. A variant of the DAB digital radio standard for mobile TV services

DSO Digital Switch Over. The process and point at which the analogue spectrum is switched off, and replaced by digital transmissions

DTPS licence Digital Television Programme Service licence

DTT Digital Terrestrial Television

DVB Digital Video Broadcasting. A set of internationally accepted open standards for digital broadcasting, including standards for distribution by satellite, cable, radio and handheld devices

DVB-H DVB Handheld

DVB-T DVB Terrestrial

EPG Electronic Programme Guide. A programme schedule, typically broadcast alongside digital television or radio services, to provide information on the content and scheduling of current and future programmes

ERP Effective Radiated Power

EU European Union

FDD Frequency Division Duplex

Frequency Number of oscillations per second of a wave

FWA Fixed Wireless Access

GE06 The agreement adopted by RRC-06 at Geneva in 2006

GHz Gigahertz: a unit of frequency equal to 1000 million (1×10^9) Hz or cycles per second

Guard band Frequency range deliberately kept vacant between assignments to give a level of protection to users on either side from interference from each other

HDTV High Definition Television. A technology that provides viewers with better quality, high-resolution pictures

Hole Punching Interference created by adjacent frequency use in uncoordinated networks: in practise receivers respond to signals in adjacent bands, consequently in uncoordinated networks, a receiver may experience significant interference from a mast that is in an adjacent band but significantly closer to it than its tuned band

IEEE Institute of Electrical and Electronics Engineers

IF Intermediate Frequency

Image Channel The n+9 channel of a signal. Due to the way signals are received, the image channel can contribute significantly to interference

IMT International Mobile Telephony

Incoming interference Interference received by a service

Interference The effect of unwanted signals upon the reception of a wanted signal in a radio system, resulting in degradation of performance, misinterpretation or loss of information compared with that which would have been received in the absence of the unwanted signal

Interleaved spectrum Spectrum in areas where the 32 x 8MHz channels used for the 6 existing DTT multiplexes are not required to provide DTT services. This spectrum may be available on a regional basis for alternative uses

Internet A global network of networks, using a common set of standards (eg the Internet Protocol), accessed by users with a computer via a service provider

IP Internet Protocol. The packet data protocol used for routing and carriage of messages across the internet and similar networks

ITU International Telecoms Union. This is an international organisation within the United Nations System where governments and the private sector coordinate, discuss and agree the logistics of global telecom networks and services

JFMG A spectrum manager for programme making, entertainment and related activities

JPP Joint Planning Project

LCD Liquid Crystal Display

Licence-Exempt (LE) Allowing anyone to use the spectrum for any application under certain specified restrictions, but typically with maximum power levels. The current regulations are the Wireless Telegraphy (Exemption) Regulations 2003 (SI 2003 No. 74), available at: http://www.legislation.hmso.gov.uk/si/si2003/20030074.htm

Main Station There are 50 main stations in the television network, which generally broadcast at high power from high masts, and thus serve large population. Main stations also provide a signal feed off to relay stations

MediaFLO A system for wireless mobile multimedia

MHz Megahertz: a unit of frequency equal to 1,000,000 (1×10^6) Hz or cycles per second

MFN Multiple Frequency Network

MOD Ministry of Defence

MPEG Moving Picture Experts Group. A set of international standards for compression and transmission of digital audio-visual content. Most digital television services in the UK use MPEG2, but MPEG4 offers greater efficiency

Multiplex A device that sends multiple signals or streams of information on a carrier at the same time in the form of a single, complex signal. The separate signals are then recovered at the receiving end

NGW National Grid Wireless

NHS National Health Service

Ofcom Office of Communications. Ofcom took over the RA's responsibility for spectrum management in the UK in December 2003

Outgoing interference Interference created by a service

PAL Phase Alternation by Line: An analogue TV standard

PA system Public Address system

PMR Private Mobile Radio

PMSE Programme Making & Special Events

PPDR Public Protection and Disaster Relief

Propagation Transmission of radio waves. Propagation characteristics depend on frequency and are affected by the environmental conditions, such as terrain and atmospheric conditions

PSB Public Service Broadcasting or Public Service Broadcaster. The Communications Act defines the PSBs to include the BBC, ITV1, Channel 4, Five and S4C

QAM Quadrature Amplitude Modulation; a modulation scheme used for transmitting data in spectrum

QPSK Quadrature Phase Shift Keying. A modulation scheme used for transmitting data in spectrum

Radio Regulations An international treaty produced by the ITU that sets out at a global level how spectrum should be used by countries

Released spectrum Spectrum that will becoming available as a result of the DSO process. This spectrum includes the cleared spectrum and the interleaved spectrum

Retained Spectrum Spectrum which will be used by the 6 DTT multiplexes following DSO (32 x 8MHz channels)

RFID Radio Frequency Identification

RIA Regulatory Impact Assessment

RRC Regional Radiocommunication Conference. Conferences of either an ITU Region or a group of countries with a mandate to develop an agreement concerning a particular radiocommunication service or frequency band

RSC Radio Spectrum Committee. A committee of spectrum administrations from 25 member states that can make decisions that are binding on EU Member states

RSPG Radio Spectrum Policy Group. The RSPG adopts opinions, which are meant to assist and advise the Commission on radio spectrum policy issues, on co-ordination of policy approaches and, where appropriate, on harmonised conditions with regard to the availability and efficient use of radio spectrum necessary for the establishment and functioning of the internal market

SDTV Standard Definition (Digital) Television

SFN Single Frequency Network

SFR Spectrum Framework Review. Ofcom consultation (published in November 2004) and resulting statement (published in June 2005) on how spectrum will be managed in the future

SFR:IP Spectrum Framework Review: Implementation Plan. Ofcom consultation published in January 2005 by Ofcom on the release of spectrum in 2005 – 08, and on extending spectrum liberalisation and trading to mobile services

Simulcast To simultaneously broadcast the same service on different platforms, or a different service on the same platform

SMRA Simultaneous Multiple Round Auction

Spectrum Mask A way of specifying the amount of power that a transmitter is allowed to transmit into neighbouring frequency channels

SQB Spectrum Quality Benchmark. The level of spectrum quality on which Ofcom's technical planning and co-ordination processes and criteria are based

TDD Time Division Duplex

TFAC Technical Frequency Assignment Criteria

UHF Ultra High Frequency (300 to 3000 MHz)

UMTS Universal Mobile Telecommunications System

VHF Very High Frequency (30 to 300 MHz)

WAPECS Wireless Access Policy for Electronic Communications Services. The RSPG adopted an opinion on this in November 2005 aiming for a more flexible spectrum management approach

WiFi, WLAN or **Wireless LAN** (Wireless Fidelity) Short range wireless technologies using any type of 802.11 standard such as 802.11b or 802.11a. These technologies allow an over-the-air connection between a wireless client and a base station, or between two wireless clients)

WiMAX Longer-range version of WiFi, adhering to the 802.16 standard

WRC World Radiocommunications Conference. A conference, held approximately every two to three years, to review, and, if necessary, revise the Radio Regulations

WTP Willingness To Pay